Museum Victoria
71380

Royal
Society
of
Tasmania

Papers
&
Proceedings

1943-44

National Museum
of
Victoria

3 FEB 1945

PAPERS AND PROCEEDINGS

OF

THE ROYAL SOCIETY OF TASMANIA

FOR THE YEAR

1943

NATIONAL MUSEUM OF VICTORIA

CENTENARY NUMBER

Edited by

JOSEPH PEARSON

and

D. COLBRON PEARSE

PUBLISHED BY THE SOCIETY

The Tasmanian Museum and Art Gallery, Hobart

15.12.1944

Price: Ten Shillings

NATIONAL MUSEUM OF VICTORIA

The Royal Society of Tasmania

Papers and Proceedings, 1943

CONTENTS

	Page
The Phreatoicoidea. By G. E. Nicholls	1
A Century of Ideas on Evolution. By Eric Ashby	159
On some new Australian Apneumonomorphae with Notes on their Respiratory Systems. By V. V. Hickman	179
Variation in Pultenaea juniperina Labill. By Winifred M. Curtis	197
The Royal Society of Tasmania, 1843-1943. By J. Somerville	199
Centenary of the Royal Society	223
Annual Report, 1943	233
Abstracts of Proceedings	237
Obituary	248

The Phreatoicoidea

By

G. E. Nicholls

Professor of Biology, University of Western Australia

(Read 16th November, 1943)

PART II.—The PHREATOICIDAE

Family **Phreatoicidae**

Right mandible without *lacinia mobilis*. Body sub-cylindrical, pleon compressed; head relatively long, generally with posterior process; cervical groove usually well developed; first peraeon segment normally not fused to the head; the telson as a rule produced into terminal projection. Maxillula usually with few setospines on apex of proximal endite; coxae of peraeopods generally free from pleura of related segments; bases of hinder peraeopods moderately, or scarcely, expanded.

As has already been noted (Part I, p. 25), the essential distinction between the Amphisopidae and the Phreatoicidae is found in the retention or the loss of the secondary cutting edge of the right mandible.

Since a similar reduction in that appendage has also taken place independently in some Amphipoda as well as in several groups of the Isopoda, that modification might be attributable to difference in dietary or mode of life, but such an explanation will not avail for the Phreatoicidae, all of which seem to be humus feeders.

Within the sub-order, the degradation or complete disappearance of this *lacinia* could, of course, have occurred independently in more genera than one and, thus, forms which lack the right *lacinia mobilis* need not necessarily be near akin, but, on the other hand, its occurrence must have a phyletic significance, since its retention can only be interpreted as an inheritance from a common ancestor. Further, the absence of this cutting edge is generally associated with a more reduced condition of some of the other mouth parts; but, to that rule, the genus *Phreatoicus* (s.s.) proves a notable exception, the maxillula, at least, being as well, or even better, developed than it is in any Amphisopid form.

Moreover, the retention of the more primitive condition of the mouth parts is usually accompanied by a greater development of the antennule, and the possession of large and prominent eyes, both features doubtless the attributes of the more active swimming mode of life.

Part I, dealing with the Amphisopidae, was published in the 1942 volume of this Journal, and the literature referred to in Part II is given on pp. 4-5 of the 1942 volume. For explanation of lettering see Part I of this paper. *Pap. and Proc. Roy. Soc. Tas.*, 1942, p. 5.

Related to this, in the Amphisopidae, seems to be the condition of an apparently shortened head, on which the cervical groove can, in many species, no longer be traced, the process of cephalization having progressed so far that, in most members of that family, the first peraeon segment appears to have undergone considerable forward shifting, with the result that its appendage (the gnathopod) lies external to, instead of behind, the maxilliped.(1) In most of the Phreatoicidae, however, the cervical groove persists and in many members of that family the forward shifting of the first peraeon segment seems to have been less marked, so that a visible gap may still exist between the attachments of maxilliped and gnathopod.

But whether the head be short or long, a character which may perhaps be important is the *relative length* of the post-mandibular part of the head; associated with this is the forward production at its anterior angle into a ' posterior process '. In *Paramphisopus palustris*, although the head appears short, the post-mandibular region is relatively long and is produced into a well-marked process. *Mesamphisopus depressus*, another species which retains many primitive features, also conforms to this type. All subterranean forms, whether Amphisopid or Phreatoicid, show, strongly marked, the opposite tendency (i.e., to head elongation), the lengthening being particularly noticeable in the region behind the mandible. *Hyperoedesipus* has no posterior process, but this is well developed in the species of *Phreatoicoides*. In general, the head in Amphisopidae is short, and the reduction in length appears to have been effected mostly at the expense of the post-mandibular region, while a posterior process is variable. It is well developed in *Amphisopus* spp., but absent in *Phreatoicopsis*.

From these facts, one may perhaps draw the inferences that (1) the primitive condition was one in which the post-mandibular region was moderately long, this condition tending to become exaggerated in many subterranean species; (2) that a posterior process, moderately developed, was probably present in the ancestral form.

Such a primitive condition of the head is characteristic of the majority of forms included in the second family of the sub-order—the *Phreatoicidae*. This includes some thirty-odd species and sub-species (more than twenty of which are new) and which are here referred to ten genera. In previous accounts, the eleven species known were all recorded under the name *Phreatoicus*.

As noted in Part I, the Amphisopidae have a pan-Australian range and occur also in South Africa, whereas the members of the Phreatoicidae are restricted to New Zealand and the Bassian region of Australia. They fall, as will be seen from the key to genera given below, into three distinct groups, most readily separated by the form of the telson, and it is of interest that the species occurring on the periphery of the area (New Zealand and the northern fringe of the Bassian) probably most nearly resemble, in condition of telson and mouth parts, the typical Amphisopids from West Australia. A few species, found only in the Great Lake of Tasmania, retain what may well be the primitive condition of the telson, and, seemingly, a comparatively slight reduction of the condition recorded for the Carboniferous fossil, *Acanthotelson*.

But the largest group of the species of the Phreatoicids cluster round *australis* or *joyneri*, and these are strictly confined to the Australian Alps and Tasmania, being in the latter country, quite widespread and abundantly occurring forms. This probably represents the latest efflorescence of the sub-order, all its repre-

(1) Part I, figs 1 and 2B.

sentatives being forms retaining what must be assumed to be the docked stump only of a primarily elongate telson, reduced mouth parts, and uropods but slightly armed.

This stump of the telson bears a terminal fringe of spines, in the great majority *four* in number. Such an armature characterizes the telsonic apex, not only of the species of *Paraphreatoicus*, but also of a very wide range of members of this sub-order, and it may well have been the number originally preserved on this telsonic stump. A few, however (constituting the genus *Metaphreatoicus*), have six spines, an arrangement which might represent either an intermediate condition in the reduction of the telson, or be due to a secondary acquisition of a third pair of these spines developing upon the lateral border of the stump. In the present account it is regarded as secondary,[1] and the more general armature of four spines is considered as the earlier condition in this family.

Key to Genera

A. Eyes large, prominent; telson with terminal projection well developed, its pleura slightly produced; gnathopod with spines on palm denticulate; spine beneath insertion of rami of uropods stout, toothed.

- B. Telsonic projection cylindrical, backwardly directed.
  - C. Telsonic projection relatively long, segments of peraeon deeper than long; bases of hinder peraeopods not expanded .... *Mesacanthotelson*
  - C¹. Telsonic projection shortened; peraeon segments as long as deep; bases of hinder peraeopods slightly expanded .... *Colacanthotelson*
- B¹. Telsonic projection slightly flattened, sharply upturned; segments of peraeon deeper than long .... *Onchotelson*

A¹. Eyes small or wanting; telsonic projection reduced to small upturned stump; pleura of telson well developed; gnathopod with spines on palm denticulate; spine beneath insertion of rami of uropod stout, toothed.

- B. Apex of telsonic projection armed with two pairs of spines.
  - C. Endopodite of first pleopod setose .... *Paraphreatoicus*
  - C¹. Endopodite of first pleopod without setae .... *Colubotelson*
- B¹. Apex of telsonic projection with three pairs of spines .... *Metaphreatoicus*

A². Eyes wanting; telson scarcely produced or upturned, its hinder dorsal border having an outline ranging from sub-triangular to a flattened convex; gnathopod with palm armed with stout sub-conical spines.

- B. Body vermiform, telson with flattened posterior surface; spine beneath insertion of rami of uropods stout, simple.
  - C. Gnathopod practically chelate; bases of hinder peraeopods not expanded .... *Phreatoicus*
  - C¹. Gnathopod sub-chelate; bases of hinder peraeopods moderately expanded .... *Neophreatoicus*
- B¹. Body sub-cylindrical, fusiform; bases of hinder peraeopods scarcely expanded.
  - C. First pleopod with endopodite bearing plumose setae; penial stylet cylindrical with several terminal spines; spine beneath insertion of rami toothed .... *Notamphisopus*
  - C¹. First pleopod with endopodite unarmed; penial stylet curved, tapering, armed with a stout spatulate spine; spine beneath insertion of rami of uropod toothed or absent .... *Crenoicus*

---

(1) There are six spines on the tapering apex of *Mesamphisopus capensis* (an undoubtedly primitive species), but only four on the similar apex of *Crenoicus mixtus*; the condition of *Paraphreatoicus relictus*, which retains the setosity of the first pleopod endopodite, is, however, almost certainly primitive and in that species only four terminal spines are present.

The family Phreatoicidae has been subdivided as follows:—

Sub-family VI.—PHREATOICINAE
- Genus—*Phreatoicus*
- Genus—*Neophreatoicus*
- Genus—*Crenoicus*
- Genus—*Notamphisopus*

Sub-family VII.—MESACANTHOTELSONINAE
- Genus—*Mesacanthotelson*
- Genus—*Onchotelson*
- Genus—*Colacanthotelson*

Sub-family VIII.—PARAPHREATOICINAE
- Genus—*Paraphreatoicus*
- Genus—*Colubotelson*
- Genus—*Metaphreatoicus*

Sub-family VI. PHREATOICINAE

Head generally without posterior process, cervical groove absent or slight, eyes obsolete; antennule short; palm of gnathopod with conical teeth which are not denticulated; suture between sixth pleon segment and telson reduced, being marked by a slight ridge; telsonic projection wanting or developed only as a small flattened, rounded or sub-triangular ledge; uropod long, spine on peduncle beneath insertion of rami, stout, simple or toothed.

The question of the appropriate place for this sub-family[1] and of the genera which should (or should not) be included has proved unexpectedly difficult. The retention of the obviously primitive condition of the maxilla in the genus *Phreatoicus* (s.s.) is associated with a moderately well-developed condition of the antennule; the reduction of the cervical groove and the occurrence of a stout, simple spine at the end of the peduncle of the uropod in that genus are, also, features generally characteristic of members of the Amphisopidae, as, too, is the flattened and reduced telsonic projection. On the other hand, the right *lacinia mobilis* is wanting; a gap between maxilliped and gnathopod is indicated, and the telson retains a projection which is perhaps the stump of an original spine.

Again, in the genus *Phreatoicus* (s.s.) the loss of the eye, the elongation of the body and of the antenna, the slender, unexpanded bases of the peraeopods, and the reduction of the setae on the pleopods may, perhaps, be attributable to a long-continued subterranean habit, but must not all be summarily dismissed as without significance, for some of these features are equally developed in *M. tasmaniae*, in which species a past history of subterranean life is not indicated.

Chilton's species *assimilis* has to be assigned to a new genus *(Neophreatoicus)*, but obviously belongs to the sub-family. The newly discovered New Zealand surface-living forms clustering around *kirkii* constitute a second new genus *(Notamphisopus)* showing affinities with both Amphisopid and Phreatoicid genera and, of the latter, chiefly with certain Great Lake species, but from these they are separated by the suppression of the telsonic spine. Finally, several blind species from the highlands of New South Wales and Victoria, also with Amphisopid affinities, seem most satisfactorily grouped with the New Zealand species. They constitute the new genus *Crenoicus*.

[1] Reference to such groups of genera as 'sub-families' may seem doubtfully warranted, the more so that a definition of the sub-family is not easy to formulate. Monod found a similar difficulty with the Cirolanidae and prefers to speak merely of 'groups of genera', noting that Racovitza had earlier named these groups as sub-families without attempting a definition. Since, in the ultimate issue, classification is merely a matter of convenience, it seems preferable to use the term sub-family for such subdivisions of a family.

Genus **Phreatoicus** Chilton

Chilton, Chas. *(Phreatoicus)*, 1882, p. 89.
Chilton, Chas. *(Phreatoicus)*, 1894, p. 185 (part).

Body vermiform with sparse, fine setae; head long, without posterior process, post-mandibular region long; eyes wanting; peraeon shallow, first segment short, free; pleon scarcely compressed, its pleura about as deep as the related segments, lower border setose; tailpiece long, telson produced into small, flattened, triangular projection as wide as long. Antenna long, mandible with first joint of palp long; maxillula with inner endite broad, wider than outer, with numerous setospines, maxilla with distal lobe of proximal endite somewhat distinct from basal lobe; gnathopods, attached behind head, practically chelate, unlike in the two sexes; oostegites differ, in immature females, from other Phreatoicids, in that at least two pairs stand erect, only two being applied to the sternum; peraeopods slender, without armature of spines, bases not expanded; pleopods reduced, exopodite with few setae, endopodite bare; uropod with peduncle styliform, rami slender and setose, spines below insertion of rami stout and simple.

Genotype. *Phreatoicus typicus* (Chilton).

Shorn of its many later accretions, the genus *Phreatoicus* is, here, restricted to *typicus* and one other, recently discovered, subterranean form, *orarii*. It would seem that it represents a very early shoot from that branch of the Phreatoicid stock which had already lost its right *lacinia mobilis* and (although this reduction has not extended to other mouth parts) had started upon the later specialization of the head, having practically lost the cervical groove and the posterior process; shortening of the head, if any had occurred, has been compensated by subsequent general elongation of the animal, consequent on long, sustained, subterranean mode of life, which is associated with the creeping habit, the development of slender peraeopods and the reduction of pleopods.

Of the many other species which have been assigned to the genus *Phreatoicus*, the sub-alpine forms, of which *australis* (Chilton) is typical, belong, in the opinion of the writer, to a wholly distinct branch, and are referred below to a genus *Metaphreatoicus*, closely related to which are two other genera *Paraphreatoicus* and *Colubotelson* with numerous species and some sub-species. The Tasmanian Great Lake species *tasmaniae* G.M.T. and some related forms appear quite distinct and constitute the new genus *Mesacanthotelson*; it is these latter which appear to link up with the surface New Zealand forms *(Notamphisopus)*, differing noticeably, however, in that in the latter the telsonic projection has been suppressed. Geoffrey Smith's species, *brevicaudatus*, is made the type of a somewhat isolated genus *Onchotelson*, gen. n.

Phreatoicus typicus Chilton

Chilton, 1882, (1), p. 279 *(Phreatoicus typicus)*; 1882, (2), p. 87, pl. 4; and 1894, p. 196, pl. 18.
Thomson and Chilton, 1886, p. 151 (part) *(Phreatoicus typicus)*.
Stebbing, 1888, pp. 543 and 687 *(Phreatoicus typicus)*; 1893, pp. 388-391.
Sheppard, 1927, p. 109 *(Phreatoicus typicus)*.

Male, not known. *Female*, body long, sub-cylindrical, although in the pleon it appears slightly compressed; its surface is set with very short setae (1882, pl. 4, fig. 15), said to be arranged more or less regularly in interrupted rows (l.c. p. 89). The figure does not support this suggestion, nor do the setae appear in the habitus figure (1884, pl. 18, fig. 1), which was, however, drawn from a dried, mounted specimen.

The *head* is not described, but, in that figure, Chilton has represented it as being as long as the first two peraeon segments, shallow anteriorly, sloping upward posteriorly to attain a depth nearly twice that at the anterior end; no trace of eyes. The ventro-lateral border of the head appears sinuous, but almost horizontal. In that figure, too, there is no hint of a cervical groove running from the postero-ventral border of the head.

Peraeon. The first segment is short, less than half the length of the second segment; it is practically as deep as the head and lengthens ventrally, its antero-inferior angle being produced towards the head. The second, third, and fourth segments are sub-equal, the latter two being longer than deep; they are described as quite rectangular, with inferior margins almost straight; the fifth, sixth, and seventh are progressively shorter than the preceding segments and deeply emarginate below. In all, the terga are sufficiently shallow to expose the ventral surface in side view.

Pleon. The first segment is shorter than the last peraeon or second pleon segment; the second to fourth are sub-equal; the fifth, which is nearly as long as the combined length of second, third, and fourth, meets its pleuron in a wide angle; while the tailpiece (including the telsonic projection) is shown as being at least as long as the preceding three segments. The terminal projection is short and slightly upturned, and the piece, in profile, has a shape rather like that of a helmet, described by Chilton as sub-conical. It is likely, however, that it gapes widely below, as it does in *orarii.*

The first pleuron is very shallow, but the pleura of the second to fifth segments are almost as deep as their related segment; all are fringed ventrally with setae. On the tailpiece, the pleuron appears as a narrow, ventro-posterior border only, fringed with very fine setae. Anterior to the uropods, the ventral margin of the pleuron of the sixth pleon segment is figured as armed with four stout, curved spines.

The projection at the end of the telson is narrow, longer than broad, and projects slightly upward, the truncate end tipped with a few setae, with a stout seta below at its base.

Appendages. The *antennule* is short, being less than half the length of the peduncle of the antenna. It consists, in the female, of eight joints, with little distinction between those of peduncle and flagellum; the last three or four joints are swollen and bear olfactory cylinders. The *antenna* is long, being about three-fourths of the length of the body; its peduncle is relatively long, the fifth joint longer than the combined length of the third and fourth; the flagellum has about thirty-five joints.

Mouth parts. The *labrum* is said not to differ in any important respect from that of *P. assimilis.* The *mandibles,* also, are said to agree essentially with those of *assimilis,* but there are three teeth only on the cutting edge of the left mandible and three on the *lacinia mobilis.* There are, presumably, three teeth on the dentate edge of the right mandible. One difference, not referred to in the text, but to be made out in the figure (1882, fig. 5) is the relatively long first joint of the mandibular palp; in *assimilis* that joint is represented as short (1894, pl. 16, fig. 5).

Lower lip. It is evident that it was this structure which was referred to as the labrum in Chilton's earlier paper, the related figure (1882, pl. 4, fig. 6) suggesting a quite peculiar condition for this organ. Later, the *labium,* correctly named, is described and, although the figure has been redrawn, it is not essentially modified. Its condition, as figured, suggests that while it may have suffered some distortion in preparation, it is, nevertheless, quite unusual in this sub-order.

Maxillula. This is remarkable for the width of the inner endite and the number (nine or ten) of its setospines. Two slender, simple, sub-terminal spines apparently constitute the remnant of the second rank of plumose setae which still persists in *Phreatoicopsis.* The outer endite has about fourteen spine-teeth arranged in two rows, while sub-marginally upon the posterior face of the lamella there are probably three or more slender, plumed setae which are not, however, mentioned or figured by Chilton.

Maxilla. In this appendage, also, the condition is quite unusual. In the basal part of the proximal endite the border is convex, while its distal portion is directed sharply mesially and a wide gap separates the apical group of setae from the proximal part of this fringe. The inner plate of the distal endite is exceptionally long and is represented in shape as sub-triangular instead of the usually obliquely-truncated oblong.

Maxilliped. This is said by Chilton to resemble the appendage of *assimilis,* except for the condition of the 'grappling setae' which are long, curved, and slightly hooked, two and three in number, whereas in *assimilis* there are said to be, on either side, two straight coupling spines slightly hooked at the end.

There is possibly, however, another detail in which *typicus* shows a resemblance to *assimilis,* to which attention has not been directed. Chilton's figure of the latter species (1894, pl. 16, fig. 10) shows a stout spine at the outer distal angle of the basis. Actually, in that species there are two stout, plumose setae at this point, obviously the homologues of the stout plumose spines so well developed in *Eophreatoicus* and in *A. lintoni,* although placed somewhat more distally; one is present in *P. orarii,* and such a spine is probably present in *typicus,* also.

Peraeopods. These appendages are known only from Chilton's description of the female. All are relatively long and slender and but sparsely setose, the coxa small and shallow, probably ankylosed[1] to the body segment (1894, p. 199) and armed *posteriorly* with a small spine; on the dactyl a small secondary unguis is indicated.

The gnathopod is slightly developed,[2] and is remarkable for the sub-triangular propod with its concave palm and practically chelate condition. The second, third, and fourth peraeopods are sub-equal and longer than the gnathopod. The fifth leg is comparatively short, while the sixth and seventh are considerably longer; in these three the basis is stouter than in the limbs of the anterior group, but is scarcely expanded. Of one specimen, it is recorded that incipient brood lamellae were present.

The *pleopoda.* Only a very brief and rather vague account of these appendages was provided in Chilton's earlier paper (1882, p. 91), but the figures (pleopods 1 and 2) are serviceable. Later (1894, p. 194), that author called attention to the fact that his earlier interpretation was mistaken, but by an unfortunate oversight he still neglected these appendages, dismissing them with the statement (l.c., p. 200) that they 'appear to be similar to those of *P. assimilis,* but are rather more slender; the fifth pleopods are very short and small'. Actually, if the figures (1882, pl. 4, figs 12 and 13) are correct, they differ from the pleopods of *Neophreatoicus assimilis* in shape, proportions, and setation. Indeed, in the notable reduction of the setal fringe, they come near to the condition, presumably developed independently, in species of the genus *Phreatoicoides.*

---

(1) Miss Sheppard (1927, p. 109) says *all are free.*

(2) It may be confidently predicted that the gnathopod of the male will prove to be large and chelate.

Uropoda. These are relatively long, slender, and but feebly spinose. The peduncle appears slight, curved, and gently concave dorsally, reaching back to the level of the telsonic apex. Its inner border is high and ends in two prominent spines; the outer border is figured as unarmed, but is stated to resemble (except for its proportions and the setation of the lower border of the peduncle) the uropod of *N. assimilis,* which (described as having a few fine setae along this border) is figured (1894, pl. 17, fig. 13) as quite setose. The two rami are short, the inner and longer being but two-thirds of the length of the peduncle; the terminal claws are immovably part of the rami. Ventral to the insertion of the rami on the peduncle is a single, slender spine, apparently without pectination.

The above account has been compiled from various references in Chilton's published papers. The species was evidently rare, for in the dozen years preceding 1894, Chilton had received only about ten specimens, *all female,* obtained from several distinct sources. The most southerly of these records is Ashburton, which is but thirty miles from Winchester, which latter is the only region to yield *N. assimilis.*

Since no descriptions, other than Chilton's, of any New Zealand species have been published, and because the writer was anxious for more information on certain details, there passed in 1925-6 some correspondence with Dr. Chilton, who very kindly sent examples of all the then known New Zealand forms, including one specimen stated to be *typicus,* coming from Ashburton. On examination, this proved to be a male, but, most unexpectedly, it differed in so many characters (other than sex differences) that there arose the question of the correctness of its reference to *typicus,* of which the male was unknown.

Almost exactly ten years later, the writer was able to spend some months (December, 1935, to February, 1936) in New Zealand engaged in the search for surface-living members of this family, this search extending to the extreme south of the South Island, and beyond, to Stewart Island. At the end of this trip, while in Canterbury on the return journey, the kindness of Professor Perceval made possible the examination of Chilton's collections and records, preserved at Canterbury College. Chance directed attention to a stray letter from Mr. Hinckney, received in 1925 at the Canterbury Museum, indicating that a packet had been despatched from the Post Office of Rangitati in South Canterbury. It had contained, as Chilton subsequently noted, some ten specimens, which were referred to *P. typicus,* but the tube had broken and the specimens for the most part dried and broken. A hasty examination, without dissection, of the balance of this small collection, suggested that the Ashburton male was probably referable, not to *typicus,* but to a new species to which Hinckney's specimens also belonged. An attempt to discover the actual place of origin of these latter took a couple of weeks and led the writer over much of South Canterbury, but eventually the locality was identified as a well, in the valley of the Orari River. Arrived there, it was found that the original well had been filled up. It had been on the property of a Mr. Scully, who stated that this 'well-shrimp' still came up in water pumped from other wells in the neighbourhood. More than a year later, this gentleman sent a tube containing close upon eighty specimens, accompanied by examples of *Cruregens, Paracalliope,* and *Apocrangonyx. Phreatogammarus* was unrepresented in this particular collection, but, as it happened, this had been secured by the writer with *N. assimilis* at Winchester the previous year. It is upon the material in this collection received from Mr. Scully and, also, the specimen sent by Dr. Chilton, that the description which follows, of the new species *P. orarii,* has been based.

Phreatoicus orarii, sp. n.

(Figs 35 and 36)

Apparently very near to *P. typicus*, from which it may be distinguished as follows:—

Body elongated, vermiform (fig. 35, *1d*, *1s*), its length nearly eleven times its width, scarcely wider than deep; surface free from ridges or wrinkling, but set with fine setae, which, on some segments at least, suggest an arrangement in incomplete anterior and posterior double rows. In the pleon, the setae form conspicuous pleural fringes ventrally and posteriorly.

Head (fig. 35, *2s* ♂) rounded, almost quarter-spherical, as long only as the second peraeon segment, its anterior border slightly concave. Antero-ventrally, there is a distinct sub-ocular notch. In side view a cervical groove is ill-defined, but from above there may be made out a constriction which seems to be the vestige of the suture between the maxilliped segment and the primary head.

Eyes are not developed, but a tiny paired oval depression might mark their place.

The ventro-lateral border of the head is sinuous and against it abuts the mandible. Anteriorly, there is a rounded fulcral prominence on the mandible which moves freely against the corresponding hollow in the head. There is no 'posterior process', but behind the mandible the ventral part of the head is deepened and produced downwardly to bear the maxilliped, in which development there appears to be a marked difference from the condition figured for *typicus*. The head can move freely upon the first peraeon segment; as noted above, this is probably true of *typicus*, also.

In the *peraeon*, the segments are sub-cylindrical. The first segment is very short; in the male, measured in the mid-dorsal line, it is only half the length of the second, but is widely expanded below; in the female, the ventral expansion is less marked. The second, third, and fourth segments are of almost equal width and practically uniform depth, but the third is slightly the longest; thence the segments decrease regularly in length but increase in depth to the seventh which, in the male, has a length once and a half as great as the first segment and a depth nearly double that segment; in the female, however, the seventh segment is actually shorter than the first. The antero-ventral corner of the second to fourth segments is produced into a quite definite process, armed each with a group of setae. In the third and fourth segments, the antero-ventral border is slightly excavated and the tergum deepens behind; in the fifth to seventh segments it is the postero-ventral border which is excavated by the coxa.

The *pleon* is comparatively long, the ratio of its length to that of the head and peraeon combined being 60 : 100. The pleura are but moderately developed, and the difference in depth between this region and the peraeon is accordingly much less marked than is the case in surface-living forms. The sixth pleon segment is, as usual, united with the telson, and almost all trace of the original suture has disappeared, a short, curved ridge running upwards from the insertion of the uropod, representing the last vestige of this boundary. It runs dorsally, parallel to the antero-ventral border of the segment, but lacks the usual series of setae or spines.

The actual telsonic projection, as seen in side view (fig. 35, *3s*), does not differ appreciably from that of *typicus*, as figured by Chilton, but viewed from above it appears *sub-triangular*, its length equalling its greatest width; it is armed apically with four short setae; laterally it is extended in narrow downturned

flanges on either side, each bearing, sub-marginally, a short, stout spine. This crescentic area, with its median projection, is separated dorsally from the rest of the tailpiece by a short, *curved* crevice. While it may be that it actually represents the true telsonic area, it seems probable that that region is more extensive and includes a larger area as far back as the insertion of the uropods, as appears from the ventral view (fig. 35, *3v*).

Anterior to the attachment of the uropod, the ventral border of the tailpiece is armed with four stout, curved, simple spines; the postero-ventral border bears a fringe of short setae, a few of which are stouter than the rest. Viewed from below, these latter borders gape widely, exposing a concave sternal region, the oval anal aperture occupying the hinder two-thirds of its length. A faint sinuous line joining the posterior border of the uropodal insertions seems to mark off the sternite of the sixth pleon segment from that of the telson.

Appendages. The *antennule* (fig. 36, *4*) has nine joints in the male (ten in the Ashburton specimen); the sixth to eighth are swollen, the ninth a mere knob (only eight occur in the female). It reaches beyond the end of the fourth joint of the peduncle of the *antenna*. This latter is nearly three-fourths of the length of the animal; in the male, the fifth peduncular joint is once and a half the length of the fourth joint but less than the combined length of third and fourth; the flagellum has forty-two joints.

The *labrum* (fig. 36, *5*) appears strongly convex, nearly as deep as wide and notched on either side near its base, thus differing considerably from the condition in *N. assimilis*, to which Chilton has likened (1894, p. 194) the upper lip of *typicus*.

Mandibles. In the male, the left mandible (fig. 35, *6l*) bears a cutting edge of three teeth; the slighter *lacinia mobilis* also has three, while near its base is a small, spined lobe; the spine row has a rounded surface fringed with doubly serrate spines arranged in horseshoe fashion. Immediately proximal to its base lie several close-set plumose setae; the molar is long and stout. The mandibular palp is robust and arises from a slight elevation bearing one stiff seta; the first joint is unusually long, being two-thirds of the length of the second. The setae arming the third joint bear a double row of setules; one, at least, of those on the first joint is minutely denticulate.

Upon the opposite appendage (fig. 35, *6r*), the cutting edge has four teeth; the *lacinia mobilis* is wanting. The spine row has a concave surface edged with numerous spiniform setae and, in life, underlies the short row of plumose setae. The molar is long with its grinding surface lozenge-shaped and placed obliquely.

The *lower lip* (fig. 36, *7*) consists of a basal region, cleft almost to its attachment, but with the two halves opposed when at rest. Each of these is produced distally into an outer lobe, strongly convex laterally, the mesial border almost straight. In the mounted preparation, these are rather widely separated, but near their proximal end, the inner border turns mesially at an angle of about 120° to pass into the distal end of the basal region. The lip closely resembles the condition figured by Chilton for *typicus*.

Overhanging (antero-dorsal to) the basal region is a paired structure which does not seem a normal inner lobe, and its relations to the basal portion are somewhat obscure. Probably it is a fold which permits of a wide divarication of the two halves, when it would form a median gutter leading directly to the mouth. On the anterior aspect of the lip, the apical region is set closely with fine setae in addition to the normal dense apical fringe.

The *maxillula* (fig. 35, *8*) closely resembles that of *typicus*, and differs from that of other members of this sub-order in the unusual breadth of the inner endite

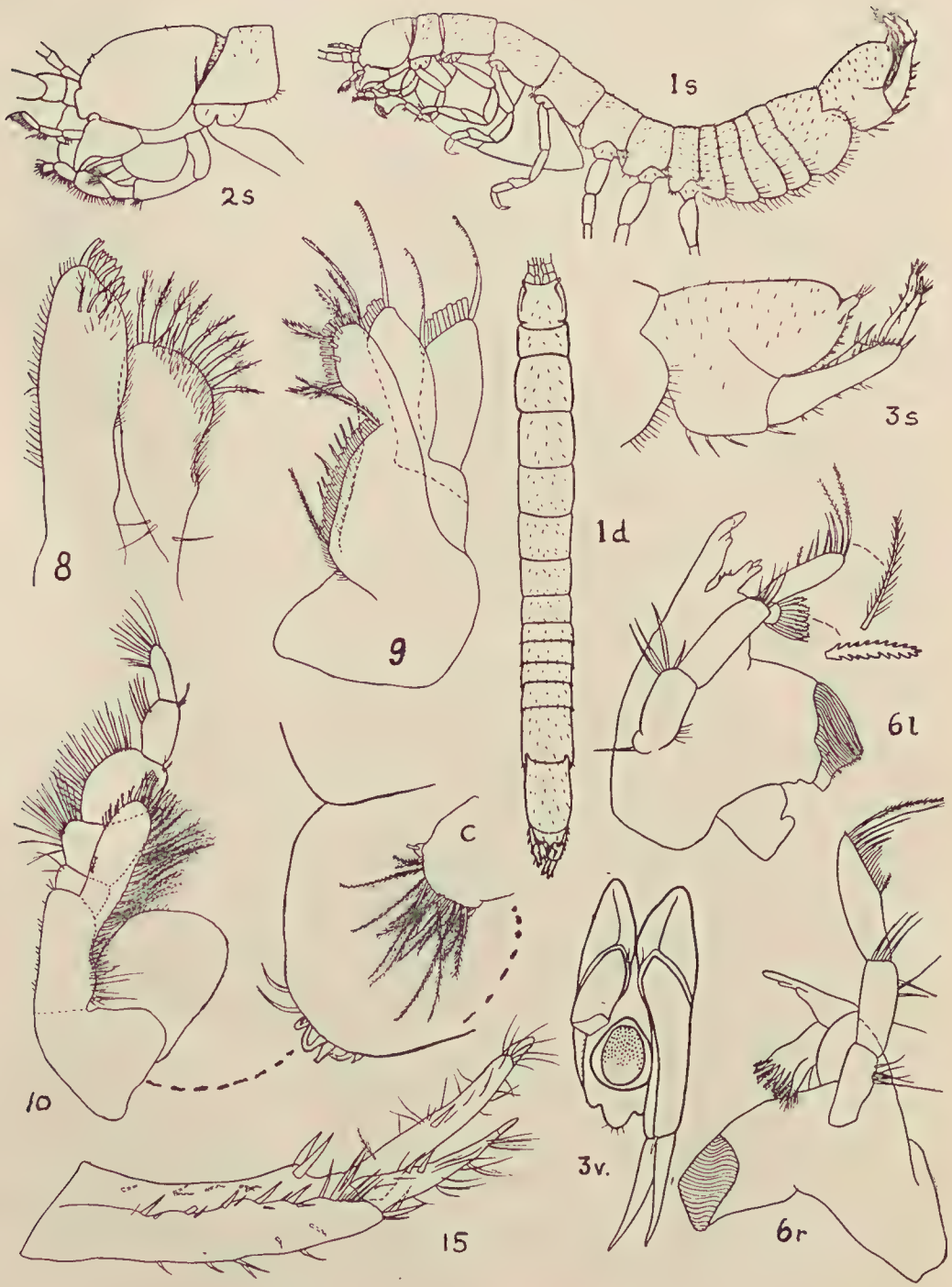


FIG. 35.—*Phreatoicus orarii*, sp. n.

(which exceeds that of the outer); it broadens distally and upon its slightly convex apex bears eight (Ashburton), nine, or ten (Orari R.) setospines.

Against the third and fourth of these (counting from the outer edge) rises, in the Orari specimens, a stiff, simple spine exactly as in *typicus*. In the Ashburton specimen, spines lie against the second and third setospines. It would seem, therefore, that the diminution in the number of setospines in the Ashburton specimen may have resulted from the disappearance of the outermost. In other species, where the number is still further reduced, the loss apparently occurs from both inner and outer ends of the row.

The outer endite bears short, simple spines arranged along its oblique distal margin in a double line, about sixteen in all. In both endites, the mesial border is rather less setose than in *typicus*, while the posterior surface of both is clothed distally with a dense fur of fine setae. Upon the posterior face of the outer endite is a sub-marginal cluster of three ciliated setae near the lateral border, these being more slender in the Ashburton specimen; they are not recorded for *typicus*.

In the *maxilla* (fig. 35, *9*) the inner endite is clearly divisible into basal and distal lobes (recalling the condition in *Mysis*), with a fringe of fine setae at the extreme proximal end followed by a row of filtratory setae, which at its distal end passes round onto the anterior face of the endite, bounding the proximal part of the lobe; posterior to the filtratory setae is a series of six to eight pectinate (biting) setae, set in a nearly straight line, along an edge which is continued as the mesial edge of the distal part of this endite. There is a gap, devoid of setae, following the pectinate series, and the apex is crowned with a dense fringe of setae, mostly plumose. The two plates of the distal endite are fringed with pectinate (biting) setae; the posterior face of the whole of this appendage is clothed with fine, hair-like setae.

Maxilliped. In this species, the coxa is unusually large, the sub-rectangular epipodite has a wide attachment, is as long as the basis and has, disto-mesially, a few short, fringing setae. In its general proportions the appendage (fig. 35, *10*), though rather less robust, agrees fairly closely with the condition figured for *N. assimilis* (1894, pl. 16, figs 10 and 11). There are about thirteen stiff brush setae along the dorsal free edge of the endite, and the inner dorsal edge of this endite is setose to its proximal end. It has three coupling hooks on one side, two on the other, which are strongly curved as in *typicus*. The dactyl is unusual in that it lacks setae on its outer border. In a spent female, the coxal lobe has the appearance of a small oostegite (fig. 35, *10c*); in the adult, but non-ovigerous animal, the lobe is much like that of other mature female Phreatoicids (cf. Sheppard, 1927, fig. 2(i)). There is, however, an important difference, for, in this earlier stage, in *orarii*, the lobe is fringed with numerous stiff setae which are hook-like (fig. 35, *c*). In the ovigerous stage, these have been replaced by long, plumose, entangling setae.[1]

The presence of such plumose setae suggests that they are respiratory, but it is possible that they may function, also, in hindering the entrance of small organisms into the brood-pouch.

The large development of these coxal lobes suggests that they retain more nearly a generalised Isopodan condition; in many members of the family they have become reduced in size.

In the female, the *peraeopods* appear to resemble closely those of *typicus* in slenderness, length, and setation. Nor, in the male of *orarii* (with the exception

[1] Such a replacement is of interest in connection with the analogous occurrence of coupling hooks and their replacement by entangling setae in the pleopods.

of the first and the fourth), do the peraeopods seem to differ noticeably from those of the female, except that they are rather more setose, as setose perhaps as in the male of *N. assimilis*, as figured by Chilton (1894, pl. 17).

First peraeopod (gnathopod), ♀ (fig. 36, *11*♀). It is principally in the hand that this appendage differs from that of *typicus*. The propod is rather stouter, its anterior border more convex, its posterior border shorter and straight and the palm sinuous, swelling convexly at the postero-distal corner into a short blunt 'thumb', thus producing practically a chelate condition; this convex bulge bears a number of slender spines. The dactyl is as long as the palm, its outer border less convex than that of typicus, the palmar border nearly straight, fringed with short setae and minutely denticulate near its distal end.

In the remaining peraeopods of the female there are no noteworthy differences from the condition recorded for these limbs in *typicus* (female).

The *oostegites* in the latter species were seen (by Chilton) only in the stage preceding maturity. In *orarii*, this stage and the succeeding have both been examined; in the earlier stage they exhibit an arrangement which has been recorded for no other species (although probably occurring in *typicus*), the oostegites on the first and fourth peraeopods being borne erect, while they lie flat against the sternites and meet mesially on second and third. In the ovigerous stage the condition is practically that of other Phreatoicid species.

There is, however, in the mature female, one important detail to note. Lying immediately mesial to the fifth leg is a sub-triangular plate, which is flattened upon the related sternite. It is apparently an incompletely developed oostegite and overlies what appears to be the opening of the oviduct. In the presence of this structure, we have the nearest approach, in a New Zealand species, to the condition recorded for *Mesamphisopus*, in which a small, free oostegite on the fifth peraeon segment is present.

In the male, the gnathopod develops a very powerful hand, which, perhaps, just misses the chelate condition. In the 15 mm. specimen supplied by Dr. Chilton (fig. 36, *11*♂) the anterior border is strongly convex, the hinder border short and straight, the sinuous palm produced into dentations which increase in size as the base of the dactyl is approached. The tip of the dactyl just over-rides the hinder angle of the palm. In one of the specimens collected by Mr. Scully (in 1937), some differences appear, probably attributable to complete maturity. In one feature, this species is peculiar, the carpus appearing capable of so considerable a rotation that the hand is carried horizontally, and turned forwardly at right angles to the proximal part of the limb, so that the palm lies in the transverse plane. Both propod and dactyl are more setose, the hinder angle of the palm has become slightly developed as a small thumb and the palmar margin here is transverse and convex, while the serrations of the more anterior part of the palmar edge are replaced by rounded prominences bearing stout conical spines. Chilton figures a rather similar condition in *N. assimilis* (1894, pl. 17, fig. 2), but the palm in that species is oblique. The dactyl is stouter and more curved, its apex not over-reaching the palm, and this distal end shows a finely denticulate condition, but a secondary unguis is not present.

Such powerful development of the gnathopod is found in many subterranean forms and probably indicates that they live in strongly flowing currents which might sweep the animal into open water. It has been pointed out (1926, p. 199) that in *Hyperoedesipus*, where this development is extreme, the gnathopod is presumably of use only in maintaining an 'earth-hold'; it is not used in catching

FIG. 36.—*Phreatoicus orarii*, sp. n.

prey, for the animal is a humus-feeder, not a predator; nor is it used in holding the female. The latter purpose is served by the fourth peraeopod, which is specially modified in varying degree in different genera.

The condition of the hand in this appendage (fig. 36, *12(4)*) in *orarii* suggests that the dactyl shuts down on to the propod as in *N. assimilis*, *M. australis*, etc., but the spines on the propod which should encounter the dactyl are rather feeble, and it is possible that the propod[1] itself may be bent upon the merus, the musculature of this joint being quite strongly developed. On the dactyl of this appendage (in the male) there is a fairly stout secondary unguis; on the fifth peraeopod this is present but smaller, and in the other peraeopods it was not to be distinguished.

Seventh peraeopod. One other detail should be noted, connected with the thoracic limbs of the male. The area of attachment of the seventh limb is shown in fig. 36, *p. 7, st.*, and it will be seen that the penis appears to spring from its mesial border. In removing the limb, it is usual to find that this structure, which contains the exserted vas deferens, will come away with the coxa. It thus has a relation comparable to that of the oostegite in the more anterior limbs of the female. The penes in this species are backwardly bent, short, and unarmed.

The *pleopods.* Of *typicus*, only the first and second pleopods were figured by Chilton (1882, pl. 4, figs 12 and 13); these agree fairly closely with the corresponding appendages of *orarii.*

First pleopod (fig. 36, *13(1)*). Apically, the exopodite carries but four or five weak plumose setae, with a few (eight to twelve) simple setae proximally on its mesial border, and one or two upon the lateral border rather more distally, one of these being practically a spine; although the endopodite appears relatively longer than in *typicus*, it is still distinctly shorter than the exopodite; the large sympodite bears fewer entangling setae and only a single spine laterally, the outer edge of the sympodite being produced into a thin membranous flange, much more marked in some other species and which, as has been suggested in Part I, p. 21, may be the remnant of an epipodite fused with the sympodite.

The *second pleopod*, in the female, except for the separation of a distal joint to the exopodite, differs little from the first; there is, however, a single short spine on the outer border of the exopodite, and there are few terminal plumose setae. In the male (fig. 36, *13(2)*), the penial stylet is little curved, but is unusually long, passing beyond the endopodite and reaching almost to the distal end of the exopodite (cf. *O. brevicaudatus*), a condition quite unlike that of *N. assimilis* as figured by Chilton. Apically, it is furnished with five stiff setae, while the inner border bears a couple of spines (not seen in the Ashburton specimen). The endopodite resembles that figured for *typicus*, but in the male the distal part seems to arise independently from a basal region, from which the penial stylet also springs—giving the effect of a two-jointed endopodite. In this appendage, also, the sympodite is well developed, the mesial 'entangling setae' sprouting in a bunch just proximal to the endopodite.

Upon the three remaining pleopods (fig. 36, *13*) are borne epipodites, arising quite near to the basal attachment of the sympodite. They are narrow, rather long, sub-oval plates fringed with few (six to eight) long *plumose* setae. The endopodite reaches its greatest length in the fourth pleopod, while in the fifth, which is shorter and broader than the preceding appendages, the endopodite attains its greatest width. In this last pleopod the expodite bears more setae on

[1] In *Amphisopus*, three joints are clearly involved, dactyl and propod shutting down together on to the merus to secure a grip on the pleuron or coxa of the female.

the second joint as well as retaining a cluster at its proximal end, while the entangling setae are now found springing from a moderately projecting lobe.

Uropod (fig. 35, *15*). The peduncle is long and slender. It is widest at its dorsal surface, which is slightly concave and highest along its inner side, which ends in two stout spines; the outer edge, armed with a few spines, runs obliquely and, distally, bears two spines; thence a series of spines passes aslant to the ventral border, the last spine of this outer series springing immediately below the insertion of the rami. As in *typicus*, the spine is simple and not very stout and is flanked by a second and much smaller, simple spine. Along the inner surface of the peduncle, there are scattered setae; its undersurface has several tufts of fine setae, thus differing from *typicus* in which, according to Chilton, these setae form a continuous series. The inner ramus, as always in this sub-order, is longer and stouter than the outer; near its attachment a single sensory (auditory?), plumose seta arises from this edge; from the peduncle nearby there projects one long, slender, bifid spine, the forerunner, perhaps, of the multifid spine of other subterranean species. In *orarii*, both rami are slender, apparently laminar, tapering to a point, being capped with a spine which is fixed; along their upper surfaces are a few slender, movable spines and associated tufts of setae.

Neophreatoicus, gen. n.

Body vermiform, head and tailpiece elongate; telsonic apex abruptly truncate; eyes obsolete; a short cervical groove present, post-mandibular region long; maxillula with proximal endite narrow, armed with but three or four setospines; bases of peraeopods of hinder group moderately expanded; pleura of second to fifth pleon segments deeper than related segments, pleopods not notably reduced in size, but setal fringes on lamellae are relatively little developed; uropods moderately long.

Genotype. *Neophreatoicus assimilis*, sp. n.

The second of Chilton's New Zealand subterranean species, *assimilis*, is, without doubt, most closely related, among extant forms, to *P. typicus* and *P. orarii*, with which it has many features in common. Some, however, of these must be recognised as due to long-continued adaptation to a similar, subterranean, mode of life, any or all of which could have been independently acquired and are not, therefore, necessarily evidence of near kinship.

Such are *(a)* the eyeless condition, and the possession of long antennae; *(b)* the vermiform elongation of the body affecting noticeably the head and tailpiece; *(c)* the proportions of the peraeon segments; *(d)* the relative shortness of the pleon, and the shallowness of the pleura in this region; *(e)* the slight expansion of the bases of the peraeopods; *(f)* the reduction of setosity of the pleopods; and, perhaps, *(g)* the elongation and slenderness of the uropods.

If the elongate condition of the head in these three species is correctly interpreted as a feature secondarily acquired in relation to the subterranean habit, then the unusual length (and shallowness) of the post-mandibular region, the obsolescence of a posterior process of the head, and perhaps of the cervical groove, also, may be consequential changes. It may well be, however, that the two latter occurred before the adoption of the subterranean mode of life.

The same elongation could have brought about a small relative displacement of the appendages in this post-cephalic region, and so account for the existence of a small gap between the attachment of the maxilliped and the coxa of the

gnathopod, as seen in lateral view. This latter joint, it should be noted, is relatively small, which is surprising in view of the fact that in this, as in most subterranean forms, the gnathopod attains an exaggerated development.

Of significant characters common to all three species, which do not seem to be in any way related to the mode of life, might be noted—

(1) The persistence of the telson only as an abruptly truncated and upturned apex, with a small *posterior* surface;

(2) The occurrence of a stout, *simple* spine on the end of the peduncle of the uropod beneath the origin of the rami.

But *assimilis* differs from *P. typicus* and *P. orarii* in several notable features: the reduction in some of the mouth parts has gone much further, while the bases of the hinder peraeopods are expanded, the pleon pleura are relatively deeper and the pleopods less reduced; rather surprisingly, however, its body is much less setose than that of *P. orarii*. Moreover, according to Chilton, a cervical groove is present and arises from the ventro-lateral border of the head, a primitive condition and one practically lost in *P. typicus*; the proportions of the body, too, cannot be derivable from those of *P. typicus*.

It seems probable, therefore, that this form became adapted to underground life at a more recent date than *P. typicus*. If so, it could have arisen from a surface-living form in which modification of the mouth parts had already gone far beyond that of the form from which *typicus* was derived, while the expansion of the bases of the hinder peraeopods was less reduced. This phyletic difference must be expressed by referring *assimilis* to a separate genus.

Neophreatoicus assimilis (Chilton)

(Fig. 37)

Chilton, 1884, p. 89 *(Phreatoicus typicus)*; 1894, p. 186, pls. 16 and 17 *(Phreatoicus assimilis)*; and 1924, p. 8, fig. 1.
Thomson and Chilton, 1886 *(Phreatoicus typicus)* (part).
Sheppard, 1927, p. 111 *(Phreatoicus assimilis)*.

Of the four New Zealand species recorded by Chilton, this was the most fully described and figured. Material available for this re-examination consisted of one specimen sent by Dr. Chilton, a second (slightly damaged) collected by the writer at the end of January, 1936, and a third sent by Mr. Pellatt of the Fish Hatchery at Temuka (near Winchester, New Zealand), taken a few weeks later. All three were males, the two more recent specimens being somewhat longer than Chilton's record. At the time of publication of his later paper (1894), Chilton seems to have had but three specimens, and it appears from an examination of his collection made in 1936, that he received subsequently very few additional specimens. It is thus one of the rarest of known subterranean forms.

Chilton has given a *habitus* figure of the female which shows many differences from the condition here recorded for the male. Chilton's original sketch was made, however, from a dried, mounted specimen, and the apparent differences between the two sexes in the proportion of segments, coxa, etc., may in part be attributed to shrinkage, etc., and are not, perhaps, as great as the figures would suggest.

Seen from above, the body is elongate, almost vermiform (fig. 37, *1d*), being of nearly uniform width, the head narrowing a little anteriorly; the length is almost exactly ten times as great as the width. Chilton has stated that, in the female, the body is of uniform breadth throughout its whole length.

In the peraeon, the depth of the segments is less than the width, but posteriorly the pleura of the pleon are downwardly produced (suggesting a compression of the body) and reach a maximum depth twice as great as the width of the pleon.

The body is smooth, with few short setae, distributed generally in small tufts. It is noteworthy that the arrangement of these suggests the remnants of two parallel transverse rows of setae in the peraeon segments and of a single row in the pleon segments.

Head. The head is as long, approximately, as the third peraeon segment; it is longer than wide and as wide as deep; its anterior border is emarginate; there is a well-marked sub-ocular notch; ventro-laterally the mandibular border is shorter than the post-mandibular. The cervical groove is said by Chilton to rise from the ventral border rather than the hind border of the head, an undoubtedly primitive condition which it would share with *Mesamphisopus*; in the specimen figured, however, this groove is not strongly developed.

Peraeon. In the male (fig. 37, *1s*), the first segment, seen from the side, appears rather more than half the length of the second. In the mid-dorsal line, however, it proves to be little more than one-third of the length of that segment (or sub-equal to the seventh), due to the fact that both its anterior and posterior margins are strongly concave,[1] this condition being much more strikingly developed than in *P. orarii.* Below, it widens considerably, just touching the posterior margin of the head from which, however, it is quite free. Chilton records for the female the length of this segment as half the length of the second.

Pleon. The first to the fourth segments are all short, sub-equal; but in Chilton's figure (pl. 16, fig. 1) there is a noticeable difference in the pleura. The first pleon segment is practically not produced, while the pleura of the second to fifth segments are practically as deep as their segments and unusually long antero-posteriorly; the fifth is as long as the combined length of the first three, while the *tailpiece* is as long as the fourth and fifth combined. It ends in a slight projection, thus differing from the more or less gently convex apex of the surface-water forms from Otago, but approaching the condition found in *P. typicus* and *P. orarii.*

Below this projection, the telson is flattened posteriorly and down-turned, this area being bounded laterally by almost rectangular corners; thence it slopes sharply forward and ventrally in slightly developed pleura, which are fringed with spinules or setae. Antero-ventrally, the pleura of the sixth segment bears four or five curved, simple spines, the last being stoutest. From the ventral border of the telsonic pleura there runs upward and forwardly a very short ridge marking a vanishing suture between the sixth pleon segment and telson. It bears two spinules, its postero-ventral end being some little distance dorsal to the upper end of the insertion of the uropods.

Appendages. These have been described in considerable detail (Chilton, 1894, p. 188), so that it will be necessary here to note a few differences observed, and to record some features previously overlooked.

Antennule. Chilton records nine or ten joints in this appendage; the present specimen show but nine, the penultimate joint being long and slender as figured by Chilton. In the female, Chilton shows five flagellar joints. The condition of the *antenna* agrees substantially with Chilton's account.

---

[1] This condition is not very common in Phreatoicids, but is frequently seen in other Isopods and in Amphipods, particularly where the animal habitually curls up completely. Related to this may be the retention of an unusual degree of development of the pleura in the pleon.

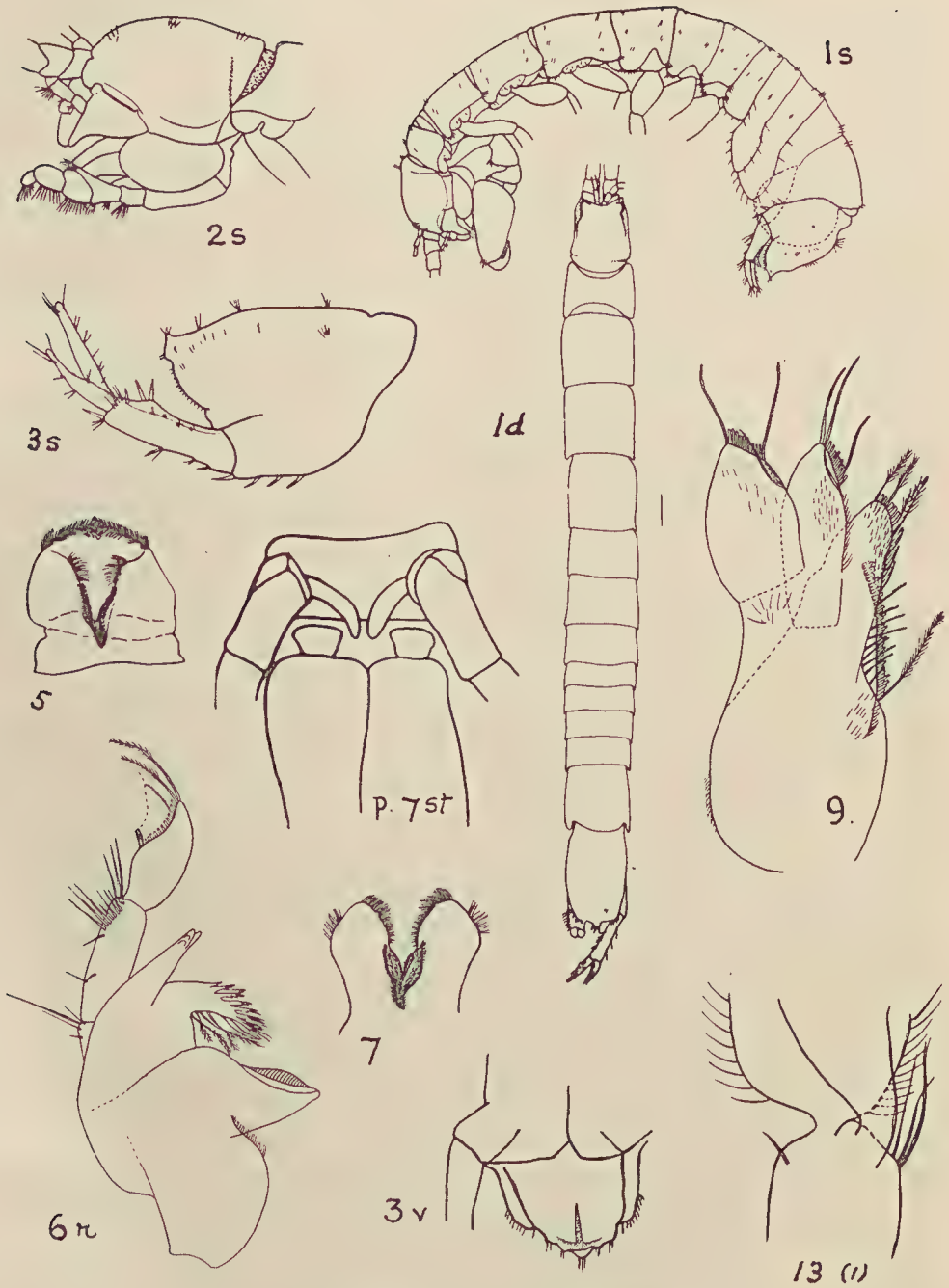


FIG. 37.--*Neophreatoicus assimilis* (Chilton).

Upper lip. Chilton has figured part only of this structure; actually, there is found an upper hinged portion, the epistome, and sutured to this, usually very firmly, in a lower portion—the labrum proper. It is this which Chilton has described. It is usually the composite structure which is figured, and in this species it is as deep as broad (fig. 37, *5*).

The *mandibles* are as described by Chilton, except that there are found four teeth in the dentate edge of the right mandible (fig. 37, *6r*) and the first joint of the palp is short. The articulation of this appendage with the head differs, however, in that its sinuous upper margin fits upon a *concave* articulation, well above the level of the post-mandibular border of the head.

Labium. Chilton's figure shows the two lobes adpressed. They can readily be separated and then have the appearance (fig. 37, *7*) more usual for this structure, the inner border of the rounded outer lobes springing from a convex surface which represents, presumably, the rudiments of an inner lobe.

The *maxillula* is as figured (1894, pl. 16, fig. 8), the proximal endite being practically as wide as the outer. Chilton's figure, although clearly a posterior view, omits the ciliated seta on the hinder face of the distal endite. The *maxilla* (fig. 37, *9*) has a rather short inner endite, but in the specimen examined, the distal portion is not bent at the angle suggested by Chilton's figure and the proximal row of filtratory setae passes well onto the face of the endite; the posterior row consists of about nine biting setae. The outermost endite is quite broad, the setae on both the outer endites being pectinate. The *maxillipeds* agree essentially with Chilton's description.

The *peraeopods* agree very closely with Chilton's figure, although both the gnathopod and the fourth peraeopod given the impression of greater stoutness; the specimen examined was a male of 14 mm. and rather larger than that figured by Chilton.

The *pleopods*, too, appear to agree quite closely with the account given by Chilton for his specimen, excepting for the details of the plumose setae on the apex of the several exopodites which were more numerous than were found in the specimen examined—in some cases twice as many. There are details, however, to which attention should be called—(i) the narrowness of the attachment of the two lamellae, so that the endopodite arises entirely mesial to the exopodite, and (ii) the production distally of the first joint of the exopodite in the hinder pleopods, so that the distal lobe is partly overlapped by the more proximal.

The penial stylet is figured as rather short; in the specimens under examination, it was strongly curved and long enough to reach the end of the proximal lobe of the exopodite; it is, also, distinctly stouter, this being probably a matter of age. It is armed apically in one specimen with four strong setae; in a second there are six or seven. Chilton mentions 'four or five' but figures seven.

In this connexion, it is to be noted that in all three examples the penes have been found to be as well developed as in other species. Chilton stated (1894, p. 196) that these were not to be seen in his specimen. It might have been supposed that his specimen was not fully mature, were it not expressly stated that the vas defrens was found packed with spermatozoa.

As regards the pleopods, it is to be noted that the condition of *assimilis* with regard to these appendages is intermediate between the condition seen in *P. typicus* (and *orarii*) on the one hand and the more nearly surface-living forms on the other.

They are long, particularly the first, second, and third, so that, although the pleura are well-developed, in life they hang partly exposed below. Not only are the actual lamellae long, but they have each a distinct stalk, notably in the second;

these are widely displaced, so that a gap between their bases is readily observed. In the first pleopod, the basal part of the endopodite is particularly noticeable, recalling the condition in *O. brevicaudatus*. In addition, the sympodite is relatively long. The exopodite of the first pair retains very nearly the primitive long-lanceolate shape which characterizes all of the Southland species, but they are less setose, bluntly rounded terminally and the plumose setae much less abundant, while the endopodite is both narrower and shorter, as well as being completely bare of setae and tending to be lobed apically.

In the sympodite, the outer distal spine is present, but is very slender. Since it is apparently a character of no value, its retention in these subterranean forms is of interest. Elsewhere it occurs, well developed, in *Mesacanthotelson* and *Onchotelson*. The lack of entangling lobes (the setae arising directly from the sympodite) is of interest as presumably a condition due to subterranean life and the desuetude of the swimming habit.

In the succeeding appendages, the endopodite is relatively smaller, oval or sub-oval in shape, while upon the exopodites the plumose setae become fewer and are persistent only apically. The epipodites, too, are relatively smaller than in the surface-water forms.

The *uropod* is noteworthy, for in its length and in its considerable extension behind the telson it resembles the condition of *M. tasmaniae*. The peduncle is long, the inner ramus sub-equal to it in length, lanceolate and laminar (rather than styliform as in most Phreatoicids), in these details strongly resembling *Mesamphisopus* and *Eophreatoicus*.

The sudden sub-terminal narrowing of the rami, to which Chilton refers, is very noticeable in this species (as it is in *H. plumosus*) and suggests the fusion of a blunt-ended joint with a primitively free spine. In the Amphisopine forms, this freedom of terminal spine (or perhaps second joint) still obtains. Beneath the insertion of the rami is a stout, simple spine flanked by a smaller spine.

Owing to the development of an actual posterior surface of the telson, the anal opening is not observed in dorsal view. Actually, it lies only just anterior to the end of the telson, the slit-like opening being set obliquely.

Colour. In life, a translucent bluish-white, becoming opaque and cream-coloured in spirit.

Size. Up to 15 mm.

Occurrence. Known from wells at Winchester, South Canterbury, New Zealand, and from a spring discharging into the Trout Hatchery at Temuka nearby.

Crenoicus, gen. n.

Body sub-cylindrical, fusiform, smooth; head of moderate length with slight sub-ocular incisure, cervical groove short, frontal slope not very steep; eyes wanting; peraeon segments deeper than long, the first short, expanded ventrally; pleon moderately long, pleura much deeper than depth of related segments, lower margin fringed with long setae, which are continued only as a sparse fringe along the hinder border; telsonic projection short, tapering to a bluntly pointed end, armed by one pair of spines laterally and a second paired spine latero-terminally;(1) telsonic pleura sparsely spined, sixth pleon pleura fringed ventrally with stout, simple spines.

(1) Sayce records but a single spine terminally in *shephardi*, and states that the toothed spine normally present below the origin of the rami is here absent.

Antennule ten-segmented, scarcely swollen apically. Maxilliped with propod broadly expanded; gnathopod of male with palm armed with a few low conical teeth; dactyl on hinder peraeopods long. First pleopod with exopodite narrow basally, widening at its mid-length and narrowing to a point apically; second pleopod, in male, with penial stylet produced distally into a stout, curved, spatulate process; uropod with but a single, toothed spine[1] beneath insertion of rami.

Genotype. *Crenoicus mixtus*, sp. n.

This genus has been placed in this sub-family only after much deliberation. For, while in a few respects it is peculiar, in most of the details of its structure it shows resemblances to a wide range of genera. Such a condition as that of the first pleopod of *C. mixtus* is met with in no other genus, although the proximal narrowing of the exopodite is reminiscent of the condition in the modified first pleopod of *Amphisopus* or *Synamphisopus*, while a similarly pointed apex is seen only in *Phreatoicopsis*. A comparable scattering of abundant setae on the anterior face of this lamella is seen in some species of *Paramphisopus* and *Amphisopus*, and the relatively reduced state of the endopodite is, also, paralleled in *A. annectens*.

The structure of the penial stylet is of particular interest in that it seems to provide the link between the two forms which this organ has assumed. It is unfortunate that Sayce has not recorded its condition in *shephardi*.

In the sub-triangular shape of its telsonic apex, members of this genus present a likeness to the condition of *Mesamphisopus* spp.; it might be considered as intermediate between that and the more rounded condition of *Paramphisopus* and *Notamphisopus* spp. as well as approaching that of *Neophreatoicus assimilis* and of *Metaphreatoicus affinis*. The number of terminal spines (four in both *C. mixtus* and *C. harrisoni*) is that widely occurring in many species, but the condition of *C. shephardi*, if correctly recorded, seems to be unique. The presence of but a single toothed spine beneath the origin of the uropodal rami in those same two species brings it into line with *Notamphisopus flavius*, *Uramphisopus pearsoni*, *Mesacanthotelson tasmaniae*, and *Onchotelson brevicaudatus*, but the simple (untoothed) condition of the relatively few and stout spines on the sixth pleon pleuron is characteristic of Amphisopine genera and of *Phreatoicus* (s.s.).

In the condition of yet another structure—the gnathopod—there is a rather different grouping; the palm on the propod is armed with a few stout, but low, conical teeth, resembling the armature found in the hand of species of *Phreatoicus*, *Neophreatoicus*, and *Notamphisopus* (amongst the Phreatoicids) and also in some *Paramphisopus* spp., although in the latter, the teeth are more strongly developed and more numerous. In members of the sub-families *Mesacanthotelsoninae* and *Paraphreatoicinae*, on the other hand, the teeth are numerous and strongly denticulated along the posterior convex border. In some Amphisopidae similar teeth occur on the propod. Comparable is the distribution of denticulation or slitting on the palmar edge of the dactyl.

Yet another example of this intermediateness is found in the way in which setospines and simple spines are grouped on the apex of the inner endite of the maxillula. In *Crenoicus* spp., of the two simple spines, one is placed outermost on the endite and the other between second and third setospine, an arrangement which occurs in the *Phreatoicidae* only in the two sub-families *Mesacanthotelsoninae* and *Paraphreatoicinae* (where it is constant) and amongst the Amphisopidae in *Eophreatoicus* and *Mesamphisopus depressus*. Since the loss of one setospine (the outermost) in other genera (*Amphisopus*, *Paramphisopus*, etc.) would bring about

[1] Sayce records but a single spine terminally in *shephardi*, and states that the toothed spine normally present below the origin of the rami is here absent.

a similar arrangement, it is probable that this was a condition acquired very early in the evolution of the sub-order. It is of interest, therefore, that in the remaining genera of the Phreatoicinae, this arrangement does not obtain.

One other generic feature may be considered, viz., that which concerns the comparative lengths of pleon and peraeon. In *C. mixtus*, the proportional length of pleo-telson to cephalo-peraeon (62 : 100) is much the same as in *australis* (58 : 100), there being relatively a slightly longer pleon; the condition is still more marked in *C. shephardi*, in which, according to Sayce, the proportions are 66 : 100. Chilton, however, differs from Sayce on this point and says that, although this may be true of the female, in the male the relative lengths of the two regions are much the same as those found in *Metaphreatoicus australis*. It should be noted, however, that Sayce's statement was based on the measurement of a male. The discrepancy may perhaps be explained by the fact that the specimens examined by Chilton came from Barrington Tops, and are specifically distinct from Sayce's example, being referred below to a new species *C. harrisoni*. Moreover, as Chilton himself recognized, differences in degree of contraction or telescoping of segments, may result in discrepant results. Thus in the specimen of *mixtus* the measurement quoted above as 62 : 100 was made along the dorsal surface with the segments in normal position; if viewed from above with the dorsal surface of the segments brought into a straight line the measurement would be 47 : 100. It will be obvious that measurements made in the position assumed by the animal at rest should give, more nearly, the correct proportions.

This feature has a certain interest, since all three of the species included in this genus are eyeless and well on the way to becoming subterranean. Now, as is well known, all modern Isopoda display a marked tendency towards the production of a shortened pleon; only in the Phreatoicoidea (particularly in the Amphisopidae) does the pleon retain a relatively considerable length, and, even in this sub-order, adaption to the subterranean mode of life is, as a general rule, associated with a further shortening of the pleon segments. It may well be, therefore, that in this rather less shortened pleon of *Crenoicus* spp. we have (notwithstanding a probable reduction due to subterranean habit) the partial retention of a condition more primitive than that displayed by *Metaphreatoicus* spp.

Crenoicus mixtus, sp. n.

(Figs 38 and 39)

Body (fig. 38, *1*, *s*, *d*) slender, smooth, short scattered setae fairly plentiful, a few longer setae being distributed sparsely on the tailpiece. Head (fig. 38, *2s*) short, little longer than the second peraeon segment; cervical groove nearly obsolete; the first segment of the peraeon short above, greatly expanded below; the second, third, and fourth segments sub-equal, longer than deep; the fifth and sixth segments sub-equal, but the sixth is deeper and the seventh slightly shorter and deeper still, its depth being almost twice that of the first segment. The ventral margins of the pleon segments are fringed with long setae, the hinder borders with less abundant and shorter setae; the first two pleon segments are sub-equal in length, but the second is abruptly deepened; third and fourth are longer and sub-equal; the fifth is as long as the tailpiece and nearly equal to the combined length of the second and third. The tailpiece (fig. 38, *3s*) is, in side view, not greatly convex dorsally, but behind dips steeply to rise abruptly in a short telsonic projection. This process, while agreeing with species of *Paraphreatoicus* in

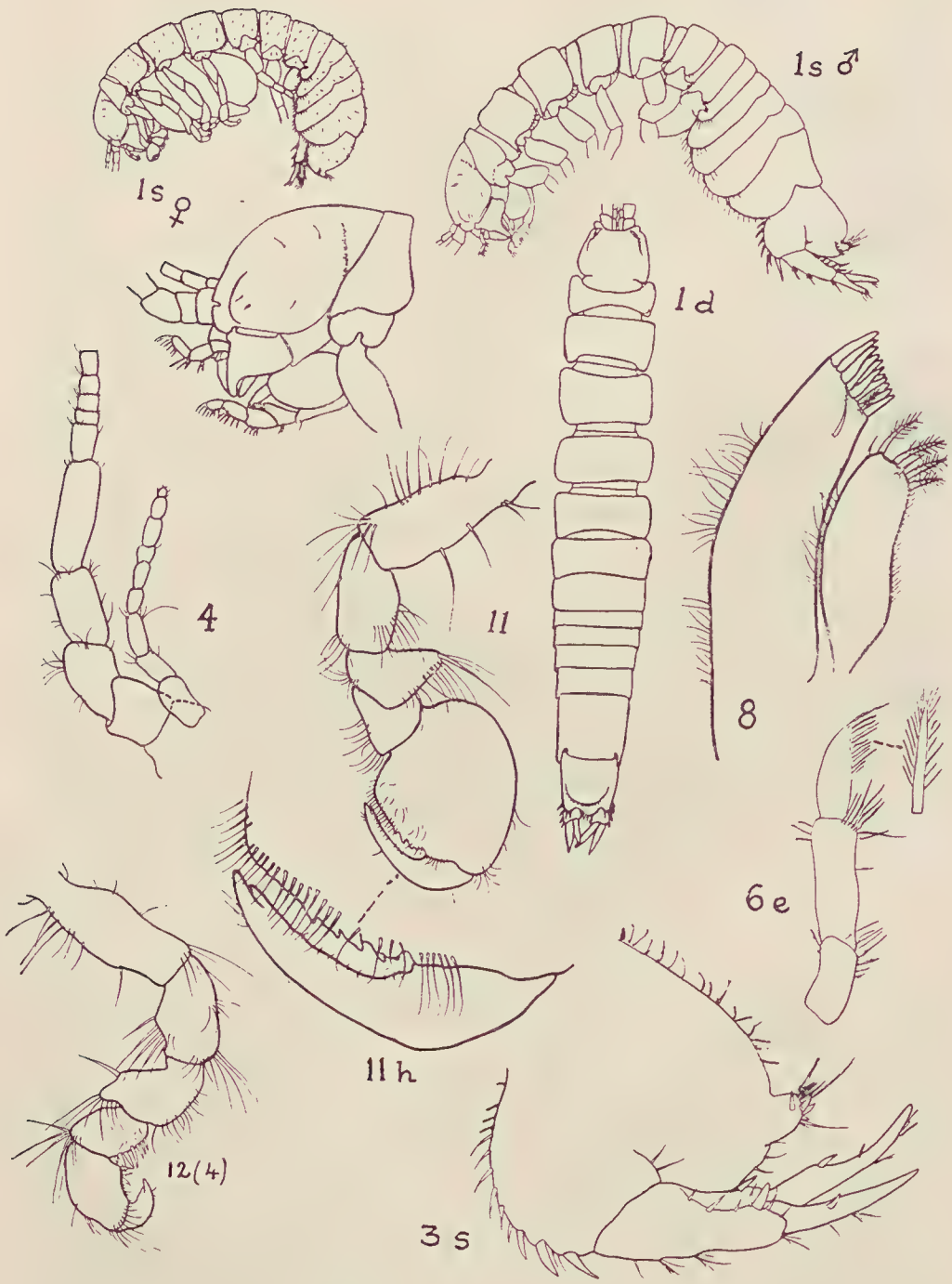


FIG. 38.—*Crenoicus mixtus*, sp. n.

bearing four spines, differs from those in the fact that it is bluntly sub-triangular in shape, and its spines are arranged in two pairs along its lateral surfaces (fig. 39, *t.a.*). In the rest of its armature, also, the tailpiece is distinctive; the anterior border of the piece slopes gradually to a rounded ventral region, armed with about seven spines of which the three hindmost are much the stoutest—*none* are toothed; flanking the last are three or four simple setae. The telsonic pleuron is defined above by a strong dorso-lateral ridge which bears a stout spine anteriorly, followed by another, and there is a third spine at the point where the ridge reaches the free border; the pleuron flares outwards and backwards much as in *Colubotelson* spp., its hinder extremity is produced into a spine and its free border bears a few setae variable in number; the suture at its lower boundary, which ends posteriorly just above the insertion of the uropod, is armed usually by two stout spinules, preceded in some by a third more slender spinule or seta.

Appendages. The antennule (fig. 38, *4*) reaches to the end of the peduncle of the antenna, and its flagellum may have as many as seven joints. The *antenna* has a length equalling that of the head and first three peraeon segments. In the peduncle the first joint is short and the second and third sub-equal and nearly twice as long as the first, the fourth slightly, and the fifth considerably, longer than the third, but the last is not as long as the combined length of the second and third joints. The *labrum* is considerably broader than long and shows a quite evident asymmetry.

The right *mandible* has four teeth constituting the biting edge; the molar is elongate; the mandibular palp (fig. 38, *6e*) has a moderately long first joint, the second only once and a half as long, and the third intermediate in length; this latter is slender and bears a single row of about eight sub-equal and doubly pectinate spine-setae, followed by an apical series of four much longer setae, also pectinate along both edges. On the inner endite of the *maxillula* (fig. 38, *8*), the usual simple spines persist, one lateral and one (the central) between the second and third setospine, but on the outer endite only one plumose seta occurs on the posterior face.

The *maxilla* (fig. 39, *9*) has the end of the proximal endite broadly rounded; the fringe of setae upon the free edge of the distal endite is relatively long; the outer endite seems folded over lengthwise upon itself.

The *maxilliped* (fig. 39, *10*) has the coxa large; the endite on the basis has about nine brush-setae and apparently only three coupling hooks; the propod is expanded; the epipodite, rounded distally, is almost as broad as long, its proximo-lateral edge fringed with setules.

The *gnathopod* (male) (fig. 38, *11*) has a fair number of setae on the basis; the ischium is relatively long for this appendage, the merus well produced anteriorly, the propod sub-globose with a long convex palm, armed only with four stout, conical teeth at the end nearer the dactyl; the free posterior border of the propod is convex and about as long as the unarmed part of the palm.

The fourth peraeopod (fig. 38, *12(4)*) has the merus rather long, the posterior border of the carpus well provided with spines, a quite definite and very spinous palm on the propod and a stout dactyl. The bases of the hinder peraeopods are scarcely expanded; the seventh peraeopod is slender and its basis is fringed with setae along both anterior and posterior borders.

The first pleopod (fig. 39, *13(1)*) has an exopodite of quite unusual shape, narrow proximally, widening sharply at its mid-length and tapering to a rounded point distally, with about fifteen plumose setae at the apex and latero-proximal to that. Its mesial border is fringed proximally with stiff spine-setae and its

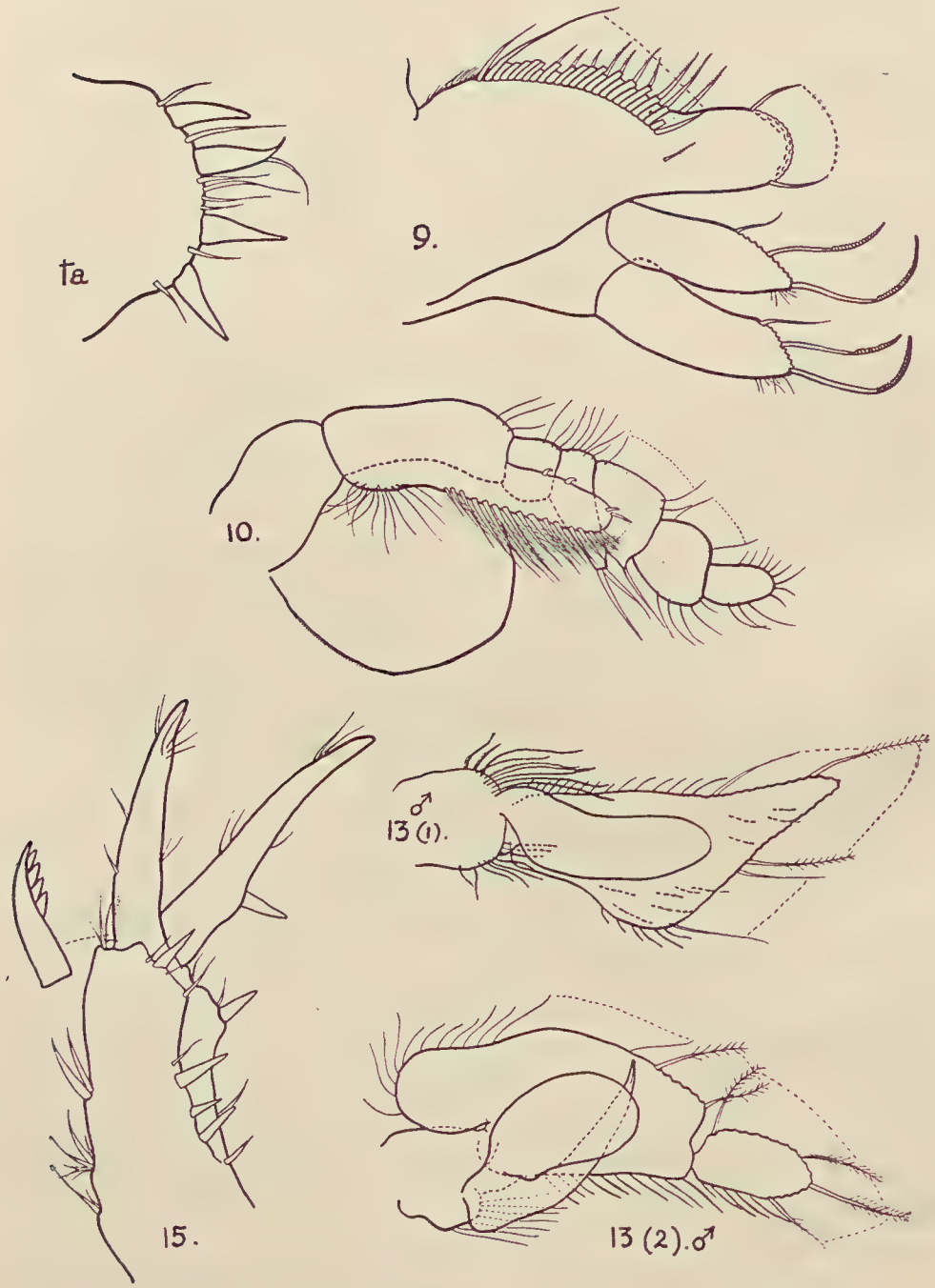


FIG. 39.—*Crenoicus mixtus*, sp. n.

hinder face has a scattered covering of setae. The second pleopod of the male (fig. 39, *13(2♂)*) also shows the unusual narrowing at the proximal end of the exopodite, which is produced into a long, proximo-lateral lobe, as long, practically, as the sympodite. The endopodite is small and the penial stylet, unarmed terminally, curved and tapering in a fashion recalling that of some of the Amphisopine forms. The third pleopod shows a long proximo-lateral lobe, but there is little trace of the sinuous outer margin of the two preceding pleopods.

Uropods (fig. 39, *15*). Moderately short, peduncle stout, its inner border rising apically, its depth at that point being almost equal to half its length; there are usually two apical spines, both very stout, but one is sometimes wanting, while the outer border, which is lower than the inner, bears usually three strong spines; the lower edge bears three tufts of mixed spines and setae, relatively long and strong; below the insertion of the rami is the characteristic stout spine with well-developed teeth; this is flanked by a couple of stiff setae. The terminal spine may be readily overlooked, since it is almost hidden by the wide base of the outer ramus. Both rami are stout, each bearing one stout spine and variable setae; the inner is almost as long as the peduncle.

Size. A large male measured 14 mm.

Colour. Pale yellowish-brown in life, fading to straw colour in alcohol.

Occurrence. Some thirty specimens, mostly small, were taken (9/1/28) on the Dividing Range near Ballarat, in springs and soaks at the source of that city's water supply. About eight of these were females, four having a brood-pouch, and three with brood lamellae. One specimen had the gnathopod of the male combined with the broadened peraeon of the female. The brood-pouch of one contained about a dozen embryos.

Crenoicus shephardi (Sayce)

Sayce, O. A., 1900, p. 25, pl. 3 *(Phreatoicus shephardi).*
Sheppard, E. M., 1927, p. 112 *(Phreatoicus shephardi).*
nec Chilton, 1917, p. 91, figs 13-17 *(Phreatoicus shephardi).*

This species was described by Sayce from a single specimen, a male of 10 mm. A comparison of the account given by Sayce with the condition found in *C. mixtus* reveals the following differences:—

The body is stout, and if Sayce's *habitus* figure is accurate, there are differences in the peraeon, for the first segment is shown as not greatly expanded below, the fifth segment shorter than either the sixth or seventh. It may well be that this quite unusual shortness of that segment (and a consequent shortening of the total peraeon length) would account for the relatively greater length of the pleon, for the proportions of the segments of the pleon are found to agree closely with those of *mixtus.*

The ventral armature of the sixth pleon pleura consists of six large, curved, simple spines, increasing in size distally and, near the base of the uropod, eight finer, simple spinules; telsonic pleuron rounded but, according to Sayce's figure (1900, pl. 3, fig. 1) projecting scarcely at all backwardly; the telsonic projection, also, is very short and, if the specimen described was normal, is quite unusual in that it has one large *median* spine and a pair of smaller lateral spines associated with some longish setae.

The *antennule* is relatively shorter, 'not reaching to the extremity of the peduncle' of the antenna. The joints of the peduncle of the *antenna* differ in relative length, the third being practically twice as long as the second, the fifth as long as the combined length of the first three joints.

The left *mandible* is figured (Sayce, 1900, pl. 3, fig. 4), but not described; the principal dentate edge shows four teeth; the spine row is not, apparently, followed by free plumed setae; the palp agrees fairly well with that of *mixtus*, but the first joint appears shorter, the second more setose and the third relatively longer. The description of the *maxillula* suggests nothing different from that of *mixtus*, but the figure indicates two plumed setae sub-apically on the hinder face of the outer endite; in both *mixtus* and *harrisoni* only one of these is found. The figure (Sayce, 1900, pl. 3, fig. 5) of the *maxilla*, if it correctly depicts the setal armature, suggests a very reduced condition of the filtratory setae, a condition, indeed, that is found otherwise only in vermiform species greatly modified for subterranean life.

Sayce's account (1900) of the *maxilliped*, which agrees quite well with his figure (pl. 3, fig. 7), indicates that this appendage is somewhat unusual; the epipodite is particularly long and produced almost to a point apically, and all of the terminal four joints of the palp unlike those of *mixtus*.

The *gnathopod* is in general agreement with that of *mixtus*, hand and palm seemingly very similar; the basis is shown as less setose. No mention is made of the sexual modification of the fourth peraeopod, which in the two species examined is a little unusual in that there is a suggestion in the spinose armature of the carpus that three joints may be involved in the clasp as is the case in *Amphisopus* spp.

Pleopods are dismissed as 'normal', but it seems altogether likely that they were not markedly dissimilar from the condition described for those appendages of *C. harrisoni*; if so, they will have differed distinctly from those of *Metaphreatoicus australis*.

In the *uropods*, differences are recorded; the outer upper margin of the peduncle is described as 'very spinose', and Sayce stresses the fact that the strong, toothed spine which is present in *M. australis* at the end of the peduncle and beneath the insertion of the rami is here not represented, apparently a unique condition, for in all other Phreatoicids there seems to be at least one spine (either toothed or simple) present in this position.

Size. Male 10 mm.

Colour. Light brown with indefinite markings of darker brown.

Occurrence. Collected (1899) by J. Shephard under moss at the source of a spring running into Wallaby Creek, Plenty Ranges, Victoria.

An unsuccessful attempt was made in January, 1928, to rediscover the locality and obtain further examples of this species; in the meantime, specimens, assigned by Chilton to *shephardi*, had been taken by C. Hedley (Jan., 1916) at Barrington Tops in N.S.W. These, however, differ in numerous characters from Sayce's species and are described below under the name *C. harrisoni*.

Crenoicus harrisoni, sp. n.

(Fig. 40)

Chilton, 1917, p. 91, figs 13-17 *(Phreatoicus shephardi)*.

This species seems to be quite nearly related to *mixtus*, with which it agrees in several particulars, some of which were not recorded by Sayce for *C. shephardi*.

The *body* is sub-cylindrical; head short, first peraeon segment short and parallel-sided; second, third, and fourth sub-equal, deep as long; fifth, sixth, and seventh progressively shorter. In the pleon, the first to fourth segments, though short, are rather longer than is usual amongst Phreatoicids, the fifth segment not being as long as second and third combined.

Appendages. The *antennule* (fig. 40, *4*) has the ten joints usual in this genus, but in this species there is shown a tendency to widen distally, in the fourth, fifth, and sixth joints. The *antenna* differs from that of *shephardi* as figured by Sayce (1900, pl. 3, fig. 3) in that the three more distal joints of the peduncle, while increasing progressively in length, decrease scarcely at all in width; these joints, too, are much less setose; the flagellum, almost complete, shows twenty-five joints.

The *labrum* is, as usual, asymmetrical, there being a relatively deep incisure for the right mandibular palp. The *mandible* (fig. 40, *6r*) agrees, in general, with *mixtus*, as also, with the figure of *shephardi* given by Sayce. On the right appendage, the second joint of the palp is long, the third joint shows a setal fringe, arranged, for the most part, in a single row of thirteen setae, which are all finely pectinate, but none show the denticulate condition found in *mixtus*. The spine row is strong, the individual teeth doubtfully denticulate.

The setal fringe upon the mesial aspect of the labium is very dense, but seems to include some spines of which one, a slender spine, stands out distally, not, however, a setospine.

Upon the inner endite of the maxillula there is the usual Phreatoicid apical fringe of four setospines, but the two flanking (sub-terminal) spines are here slightly ciliated. The outer endite has but ten stout apical spines, some being denticulate. On its hinder face, the place of one spine is taken by a relatively long and slender setospine, while more proximally are two feebly plumose setae, indicated, also, in Sayce's figure (1900, pl. 3, fig. 6) of *shephardi*—only one being found in *mixtus*.

The row of filtratory setae which partly constitutes the mesial fringe of the proximal endite of the maxilla appears much better developed than in *shephardi* (Sayce, 1900, pl. 3, fig. 5). Lateral to it is a slender, simple spine, while behind it is a supporting row of about nine to ten biting setae; the terminal lobe of this endite is somewhat expanded, but narrows apically and bears a sparse fringe of stout, biting spines and half-plumed setae; the two outer endites have a fringe of but few doubly-pectinate spines and setae, relatively shorter than in *mixtus*.

The *maxilliped* differs little from that of *shephardi*; there is the same widely expanded propod, while the epipodite is long, pointed distally, and without bordering spinules; a short fringe of setules proximo-laterally, as in *mixtus;* four coupling hooks are found upon the endite of the right appendage.

Chilton (1917, p. 93, figs 13, 15) has called attention to differences between gnathopods of male and female, and has stressed the enlarged condition of the propod in the male. Actually the propod is not especially developed, although large development of this joint is a fairly constant feature in species which have adopted the subterranean or burrowing habit. The palm (fig. 40, *11h*) of this species differs slightly in its armature from that of *mixtus*, but probably resembles quite nearly that of *shephardi*; the free posterior border of the joint is concave. The fourth peraeopod (fig. 40, *12(4)*) of the male is unusually stout and differs in some details from Chilton's account, the propod being widely expanded, without evident palm and without spines, suggesting that the tip of the dactyl shuts down on the abundant spines on the carpus.

The basis of the seventh peraeopod (fig. 40, *12(7)*) appears to be less expanded than is suggested by Sayce's figure (1900, pl. 3, fig. 9) for these limbs in *shephardi*, its anterior border is free from setae; the male appendage, arising from the coxa, is quite unusually long and armed by one stout spine at about its mid-length.

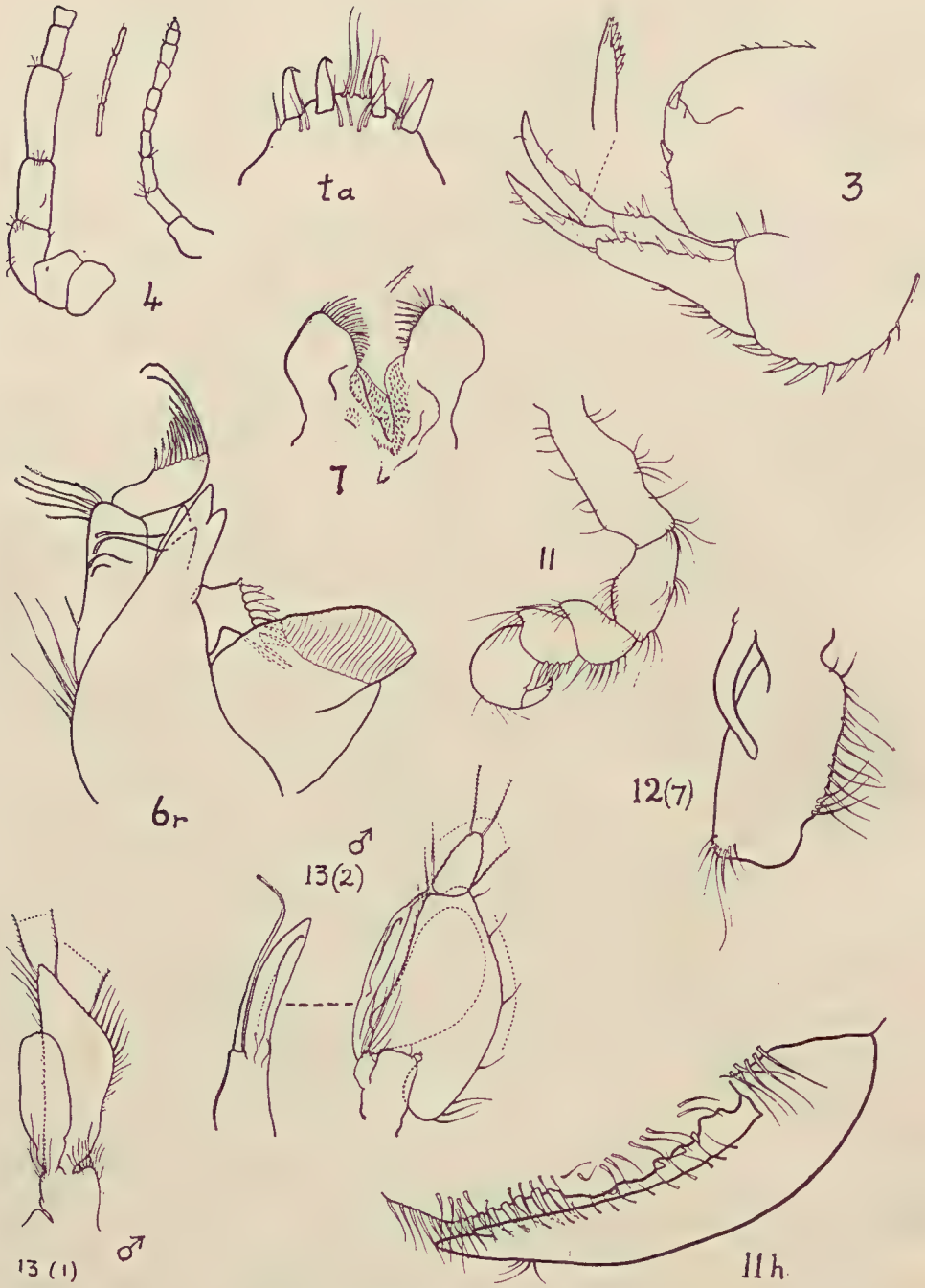


FIG. 40.—*Crenoicus harrisoni*, sp. n.

Concerning the pleopods of *shephardi*, Sayce says merely 'pleopods normal'; Chilton makes no reference to them, and yet both in this species as in *mixtus*, the shape of the first pleopod of the male is quite unusual (fig. 40, *13(1)*). Indeed, insofar as outline goes, it can compare only with that of some *Amphisopus* spp., although the proximo-lateral emargination seems to be unrelated to any transverse fold across the exopodite, such as found in *Amphisopus*. The endopodite is oval, much longer than in *mixtus* with a distinct basal region and emarginate distally.

The second pleopod (fig. 40, *13(2)*) of the male is remarkable chiefly for the condition of the penial stylet which, outside of this genus, has no close parallel within the sub-order. It is long, with its mesial border curved, and its lateral margin straight, and is armed terminally by a stout spine in addition to the longer structure of hollowed spatulate shape, which alone completes the stylet of *mixtus*.

The uropod conforms quite nearly to the figure of this appendage given by Sayce (1900, pl. 3, fig. 10), but it differs in that, in *harrisoni*, there is developed an unusually long and strong denticulated spine at the end of the peduncle. Since the presence of at least one spine here is such a constant feature in Phreatoicids, it might have been supposed that this spine was present in *shephardi*, obscured by the outer ramus, were it not that Sayce twice insisted that it was wanting.

Size. 13·5 mm. (male).

Colour. In preserved specimens, palely straw-coloured.

Occurrence. Collected by the late Professor Harrison at Mount Royal (Barrington Tops); presumably identical with that collected nearby some years earlier (Jan., 1916) by C. Hedley.

NOTE.—Two or three specimens in the collection of the Australian Museum taken at 'Crystal Springs' near Armidale (New England), N.S.W., should probably be referred to another species.

Notamphisopus, gen. n.

Body sub-cylindrical and fusiform, setae moderately abundant; the head short, the mandibular region usually longer than the post-mandibular; the 'posterior process' reduced or absent; the peraeon deep; the pleon with pleura well developed, tailpiece practically not produced into a telsonic projection, and the telsonic pleura may actually project behind the telsonic apex. The antennae short; the maxillula with inner endite narrower than outer with few setospines; the maxilla with distal part of proximal endite not sharply marked off from basal part; the peraeopods stout, spinose, bases more or less expanded; the fourth peraeopod sexually modified; the first pleopod with exopodite and endopodite fringed with plumose setae; the uropod with inner border of peduncle raised, rami lamellar, spinose; spine beneath insertion of rami, toothed.

Genotype. *Notamphisopus littoralis*, sp. n.

Notamphisopus littoralis, sp. n.

(Figs 41 and 42)

The body (fig. 41 *(1)*), seen from above, appears widest at the fourth peraeon segment, the length in the male being six times the greatest width; the sub-cylindrical peraeon has a width once and a quarter its depth; in the pleon the greatest depth is slightly greater than the maximum width of the body. The surface, which shows no wrinkling or sculpturing, is sparsely set with fine setae,

whose arrangement in the peraeon, at least, suggests incomplete double rows. In the female, the peraeon is rather wider, the body length being only five times the greatest width, which latter is sub-equal to the greatest depth of the pleon, these being proportions which agree closely with those of *Eophreatoicus kershawi.*

These measurements, however, depend to some extent upon the state of preservation of the individual. Commonly (as in the male figured) the terga in the peraeon appear to be separated by wide inter-segmental gaps. In this species, at least, these gaps are more apparent than real, for an unusually wide posterior border of each of these terga seems bevelled and is apparently capable of sliding beneath the anterior border of the succeeding tergum. Related to this telescoping, the postero-ventral fringe of setae, normally marginal, is here sub-marginal. In the female figured (in which the setae are not represented) the terga are seen in the closely approximated overlapping condition.

The head (fig. 41, *2*) is short and rounded, depth and length being approximately equal, the width slightly greater; in front it rises steeply from the transverse anterior border which is only shallowly concave. In the male, the head is scarcely longer than the second peraeon segment, but in the female it appears nearly equal to the combined length of first and second peraeon segments. A minute oval depression, near the anterior border of the head, may mark the original position of an eye—now entirely obsolete. The sub-ocular incisure is well marked, while behind the mandible is a vestige of the posterior process. From the hinder border of the head, at about half its depth, rises a short but quite definite cervical groove, widely interrupted dorsally. The post-mandibular region is deep but short, its length about half that of the mandibular border.

Peraeon. The first segment is short, being, *in the mid-dorsal line,* approximately half the length of the second segment; the third is a trifle the longest; the fourth is sub-equal to the second; the fifth, sixth, and seventh are progressively shorter. In all of these the antero-ventral angle is produced downwardly, in front of the coxa, into a process armed with setae. Postero-ventrally, the first segment is rounded off considerably; in the succeeding three, the corner is less truncated, and on each there is a short, setal fringe. This shaping of the terga would appear to be related to the ability of the animal to roll up more or less completely.

Pleon. The first segment is very short; the second, third, and fourth are slightly longer and, in the female, sub-equal; the fifth is longer than the combined length of the third and fourth; the pleura of the second to fifth segments are deeper than their related segments, a notch generally marking the junction. The ventral borders of the pleura are fringed with long setae, and, in the male, much of the posterior borders as well.

The tailpiece (fig. 41, *3*) is scarcely as long, in the mid-dorsal line, as the fifth pleon segment and practically equals the head in length. The telson is not produced apically and practically not upturned; seen from above, its transverse hinder border is very gently convex and fringed with setae, while the telsonic pleura project strongly backwardly, giving to the tailpiece, in dorsal view, an outline little different from that of the preceding (fifth) pleon segment. The antero-ventral border has a fringe of about twelve or thirteen curved, slender spines (only eight in the female), increasing in length posteriorly. The postero-ventral border bears a fringe of short setae, which are replaced, dorsally by spines, three or four in number. The suture separating the telsonic pleuron from that of the sixth pleon segment is short, but quite definite and bears two or three stout

FIG. 41.—*Notamphisopus littoralis*, sp. n.

spines. It meets the ventral border some distance above the insertion of the uropod, leaving a distinct gap between that appendage and the telsonic pleuron.

Owing to the absence of any backward projection of the telson, the anal opening, which is strictly terminal (fig. 41, *3v*) may be visible on the rounded posterior end of the body, viewed from above (fig. 41, *1d*). This condition is found in several New Zealand surface forms, and a comparable vertical opening, terminally situate, occurs in *Phreatoicopsis*. In the majority of Phreatoicids, however, the anus is found to open postero-ventrally or even ventrally into a concavity, well forward of the base of the telsonic spine. Thus, while its terminal position in *Notamphisopus* may be due simply to the reduction of the telsonic area and spine, it may equally be the retention of a primitive condition.

Appendages. The antennule consists of eight joints in the male, fewer in the female, with little distinction between those of peduncle and flagellum, except for size and that some of the more distal (flagellar) joints are swollen and bear olfactory cylinders.

The *antenna* (fig. 41, *4*) is short, less than one-third of the length of the body, and moderately robust. Its condition is unusually primitive, inasmuch as, apart from decreasing thickness, the several joints of the peduncle are not strikingly different; in length, the third and fourth are equal, the fifth only two-thirds of the combined lengths of third and fourth; there are seventeen joints in the flagellum. Many of the joints, both in peduncle and flagellum, show well-marked fringed scales.

Labrum (fig. 41, *5*). This is stout, attached above to a well-developed epistome; the convex outline of its ventral border is uneven and is edged by an irregular fringe of longish setae; the structure is unusually asymmetrical, being irregularly excavated where the mandibular palps rest upon its lateral borders, that of the right side lying in a deep notch.

The *right mandible.* Examined, in position, this is seen as a sub-triangular body with a short, straight, nearly horizontal, hinge-like articulation with the ventro-lateral margin of the head, this articular line appearing less than, or about, one-half of the length of the appendage. In front of this hinge, the large, rounded fulcral process is stout and is directed upwards and forwards to rest against a hollow on the ventro-lateral border of the head. Behind the hinge, the dorsal border of the mandible curves away to bulge into the rounded acetabular process, which fits upon a convexity at the forward end of the post-mandibular region. The anterior border of the triangle is nearly vertical, its apex—the dentate cutting edge (with four teeth)—being incurved mesially; the palp springs from the anterior border within its upper third. The posterior side of the triangle is sinuous, being at first concave and then convex.

If the mandible be rotated outwards until it is loosened sufficiently to be turned completely upwards against the side of the head, the mesial surface is exposed. The spine row is long, lying immediately proximal and internal to the *pars incisiva*, the massive molar presents its truncated end as a ridged oval surface; in side view this surface appears somewhat saddle-like; the large, sub-quadrangular opening of the adductor muscle occupies much of the inner surface.

If the left mandible be similarly examined, several differences will appear. The fulcral projection is more remote from the hinge-like articular edge, which is less noticeably distinct from the acetabular process. The fulcral process seems to spring from the anterior surface of the base of the molar, and this latter has an altogether different shape, the grinding surface appearing an irregular long oval in surface view. The adductor muscle is presumably more powerful, as the

opening on the inner face of the mandible is larger, and differs, too, in shape from that of the opposite side. There is present, of course, in addition, a *lacinia mobilis*, which is not very strong and has but two small teeth; the spine row differs in shape. The principal dentate edge bears four teeth. Free plumose setae between spine-row and molar were not seen, but the inner surface of the spine row and its base is heavily setose.

Differences were not observed in the two palps, but it should be noted that accurately to determine differences in proportions in the lengths of the three joints, measurements must be taken when the palp lies wholly in one plane. As it is carried in life, the palp is usually bent so that the terminal joint is carried in front of the labrum or epistome, and measurements made from sketches of the entire appendage with the palp attached are liable to be misleading. Reliable measurements are to be obtained only if the palp be removed for examination.

In one specimen, the first and third joints were sub-equal, the second exceeding them by one-fifth only of its length, but in others the second was relatively considerably longer. There is some slight variation in the number and disposition of the setae; it is to be noted, however, that on the terminal joint the setae are set *in a single row*, except at the apex, where two stout, additional setae are present, forming a second rank. These setae (fig. 41, *6e*) are finely pectinate along two edges.

The *labium* (fig. 41, *7*) is markedly different from that of *typicus*, and shows a condition approaching that seen in the great majority of Phreatoicids. In the figure, the setae on the mesial borders are merely indicated; they are, in fact, more abundant, although the fringe is less dense than in Australian Phreatoicids.

Maxillula (fig. 42, *8*). The inner endite is short but moderately wide so that the four setospines borne on its free end are widely spaced. The sub-marginal row consists of two slender spines, one against the outermost and the other between the second and third of the setospines; this inner spine is finely pectinate; the outer (on both appendages) bears but a single cilium. If these two sub-marginal spines are the homologues of those found in *P. orarii*, then two setospines have disappeared apparently from the outer border and three from within.

The outer endite has about thirteen stout spines apically (some of which are toothed) and, almost mesially, one small setospine; there is but one plumose seta on the posterior face of this endite.

The *maxilla* (fig. 42, *9*) retains in the inner endite the bent condition noted for *P. typicus*, though to a lesser degree. There is a smaller gap between proximal and distal setae, the distal fringes ranging from stoutly denticulate to feebly plumose and forming a double row. In the proximal portion there is the usual close-set row of filter setae anteriorly and, behind, a row of about fourteen biting setae. The two outer endites are relatively narrow and not very long. Both have a truncate apex closely fringed with long, pectinate spines. The distal part of the posterior surface of all three endites is clothed with fine setae, which may be very dense (fig. 42, *9'*).

Maxilliped (fig. 42, *10*). As in *P. orarii*, the coxa is very large and the epipodite long, sub-ovate and unarmed. The basis (not including the endite) is little longer than the coxa and shorter than the epipodite, the endite being nearly as long as the proximal part of the basis. It is fringed proximally with fine setae, continued on its distal two-thirds with eight to ten brush setae, many of which are chiefly or entirely ciliate on the distal side only and bare at the tip; these pass at the summit of the plate, without transition into shorter and relatively stouter

F.G. 42.—*Notamphisopus littoralis*, sp. n.

setae which have minute pectinations only in the apical part; on its ventro-mesial border are two coupling hooks. The palp is long, heavily setose, the merus and propod both reaching an unusually large size; the dactyl has setae on its lateral border.

In the female, the oostegal plate borne on the gnathopod had a relatively large anterior portion folded forward, in the usual manner, against the base of the maxilliped. The other plates were in no way remarkable. All were bordered along their free edge with a close fringe of long setae.

The *gnathopod*, in the female, has the propod small, sub-triangular in shape with a concave palm. The palmar edge of the dactyl has a series of parallel slits, giving the effect of a rank of square-ended, closely-fitting teeth.

In the male (fig. 42, *11*) it is short and stout; the coxa is large, fused with its segment, usually breaking in removal, its anterior border bearing setae and a fine fur of very short setules. The several joints are but moderately setose, the basis nearly as long as the succeeding three joints, the ischium stout, the hand, in the male, very strong and sub-globose in shape. The length of the propod is greater than that of the basis, its width almost equalling its length. The posterior border is about two-thirds the length of the palm, which is short, nearly transverse, and armed with stout teeth, rising in an increasing elevation from an almost straight border. The dactyl is a stout, strongly curved joint, almost as long as the basis, its unguis slightly overlapping the palm.

The second and third *peraeopods*, in the male, are stout and setose, the ischia long, the condition of the third propod resembling, though less strongly developed, the condition found in that joint in the fourth, which is sexually modified in the male; the fourth (fig. 42, *13(4)*) is the shortest of the peraeopods. The propod appears to be concave on its posterior border, but actually the excavation is developed principally on the inner surface.

The fifth shows a very slight development of a flange upon the hinder edge of the basis and bears some spines as well as stout setae; the sixth and seventh (fig. 42, *13(7)*) are progressively longer and stouter; the expansion on the basis is longer but not greatly wider than on the fifth, and more heavily spinose. The penis, which comes away with the limb, is armed laterally with a few short, stiff setae, and is strongly curved and rounded apically.

Pleopods. In the pleon appendages, this and its nearly related species has retained a strikingly primitive condition. The sympodite of the first pleopod (fig. 42, *13(1)*) is stout, squarish in outline but narrowing distally, its outer margin produced laterally (from its anterior surface) into a thin membranous lamina closely fringed with strong, finely pectinate setae—highly suggestive of a reduced and fixed epipodite. In addition to the marginal setae, there is one bunch of stout sub-marginal setae of unusual length. Sub-marginally, from the inner distal angle of the sympodite, arise, close together, three or four long and stout entangling setae, some being pectinate; there may be a few related but slighter marginal setae. These collectively interlock with those of the opposite appendage so that the pair move as one.

The exopodite and endopodite are long-lanceolate in shape and *practically equal in size*, for, although the exopodite may extend slightly beyond the endopodite, the latter arises rather more proximally from the sympodite. *Both are fringed heavily with setae.* In the exopodite; this fringe extends uninterruptedly around its entire border and for the most part the setae are long and plumose. In the

endopodite there are mesially and sub-apically only four or five plumose setae, but along the lateral border this series extends about two-thirds of its length, then giving place to long, flexible, simple setae. A comparable setose condition of the endopodite is seen, beyond this genus, only in *Mesamphisopus*.

In the middle line between these pleopods there is a bulbous process rising from the sternite, recalling that seen in *Eophreatoicus*.

The *second pleopod* (fig. 42, *13(2)*) is the only one, in this genus, which shows differences associated with sex. The sympodite is large, but the lateral membrane is wanting and three or four setae only are found on this border; mesially, pectinate entangling setae arise in a tuft from a distal prominence.

The exopodite, although little longer than that of the first pleopod, is the longest of the series. It is divided into two joints, in the usual Phreatoicid fashion; the proximal is long, the distal is short and sub-oval; in addition, on both the lateral and mesial borders of the first joint, there is a proximal extension into a lobe, that on the lateral border reaching upwards almost to the sternite.

Two-thirds of the outer border (including much of the distal joint) is fringed with plumose setae; the setae along almost all the inner border are finely pectinate, as, too, are many of the setae on the lateral proximal lobe of the first joint.

In the female, the *endopodite* is long, oval, rather shorter than the first joint of the exopodite and bears no fringing setae. In the male, the inner border of the endopodite is separated, almost to the base, as the penial stylet, a scroll-like structure which curves outward at the distal end, around the free end of the endopodite. It is armed apically with five stiff setae, some or all of which may bear short pectinations; proximally, on its mesial border, are four curved, pectinate setae not shown in the figure. It is jointed at its attachment to the endopodite, the proximal region being strongly muscular, the endopodite, too, appearing divided at this level.

The *third, fourth,* and *fifth pleopods* are all alike, except for a progressive decrease in length and a corresponding increase in width; they differ markedly from the second pleopod in the possession of an epipodite which is a thin, sub-oval plate, attached narrowly to the sympodite, very near to its junction with the sternite. For about two-thirds of its perimeter, the epipodite is fringed with long, flexible setae, some of which are shortly pectinate.

The increasing width of the lamellae in these hinder peraeopods is associated with a lateral displacement of the distal process (from which arises the tuft of entangling setae), which becomes more and more elongated until, in the fifth pleopod, it appears as a strongly projecting outgrowth, directed mesially and bearing a large group of long entangling setae, some with a double row of short pectinations.

Upon the exopodites, the plumose setae show a progressive decrease in abundance, more of the fringe being made up of long pectinate, or even simple, setae.

In the fourth and fifth, part of the proximal mesial border of the first joint of the exopodite is bare of setae. The endopodite, relative to the exopodite, becomes smaller and wholly lacks setae.

Uropods (fig. 41, *15*). These are comparatively short and stout. The peduncle has a broad and deep base, its length being barely twice its greatest depth, and it is twice as broad distally as at its base. Along its ventral edge are several clumps of spines and setae, and some ventro-mesial in position, not seen in external view. Its dorsal surface is unusual in that it appears rounded instead of concave and the inner border little higher than the outer, its distal apex having two particularly

stout spines, only one being mesial, the outer rising about the middle of the width (cf. *Phreatoicoides*); right and left marginally are a few spines and, in some specimens, the outer row may scatter on the outer surface. The inner ramus, scarcely shorter than the peduncle, is setose (some setae being plumed sensory) and capped with a terminal fixed spine, the outer ramus about three-fourths the length of the inner, smaller and less setose, but bearing one spine about its mid-length. Beneath the insertion of the rami is one stout, toothed spine and a smaller simple spine.

Colour. In life, scarcely translucent, dull greenish-yellow to grey, harmonizing well with the mud in which it occurs. In spirit, it fades to pale straw-yellow.

Size. The largest males measure nearly 14 mm.

Locality. The Reserve at Pounawea, a tiny hamlet near the mouth of the Catlins Estuary, some ten miles only from the extreme southern end of the South Island of New Zealand. Taken 8-9/12/1935 in springs (and the ditches draining from them) within a hundred yards of the shore and practically at sea level. Associated with it, in the drains, were abundant *Paracalliope* and a few *Apocrangonyx*.

Notwithstanding the many evidences of the adaptation of this species to subterranean life, it retains to an unusual degree the armature of spines and setae normally associated with the free living habitat. In many features (as, for example, the shape of the head as seen in dorsal view) it shows a strong likeness to *M. setosus*. In the occurrence of plumose setae on the endopodite of the first pleopod, and, perhaps, in the sub-equality of the joints of the mandibular palp, there is a retention of features more primitive than those of *P. typicus*, but in the condition of the mouth parts generally there has been considerable simplification by loss. In the presence of a toothed spine below the insertion of the rami of the uropod—the species of this genus differ from those of *Phreatoicus* and *Neophreatoicus* and agree with *Mesacanthotelson*, etc.

Notamphisopus flavius, sp. n.

(Figs 43 and 44)

Very near to *N. littoralis*.

Body sub-cylindrical (fig. 43, *1s*, *1d*) fusiform as seen from above, narrowing rather less than *N. littoralis* at head and tailpiece.

The greatest width, attained in the fourth peraeon segment, is rather more in the female and less in the male than one-sixth of the entire length of the body and is scarcely less than the greatest depth of the pleon. The surface is smooth and there are rather fewer setae than in *littoralis*, and there is a more evident arrangement of these setae in two bands in each segment, the bands consisting of a single or, occasionally, a double row of setae. As in *littoralis*, the terga of the peraeon, in lateral view, display a raised region considerably less than the area of the segment, bounded before and behind by a wide bevelled margin.

The *head* (fig. 43, *2*) is short, rounded, high in front, rather longer relatively in the female, the extra length (as compared with the female of *littoralis*) being chiefly in the post-mandibular region. Otherwise, the head agrees closely with the condition described for *N. littoralis*, but the shape of the mandible (in its natural position) seems to differ in the two species.

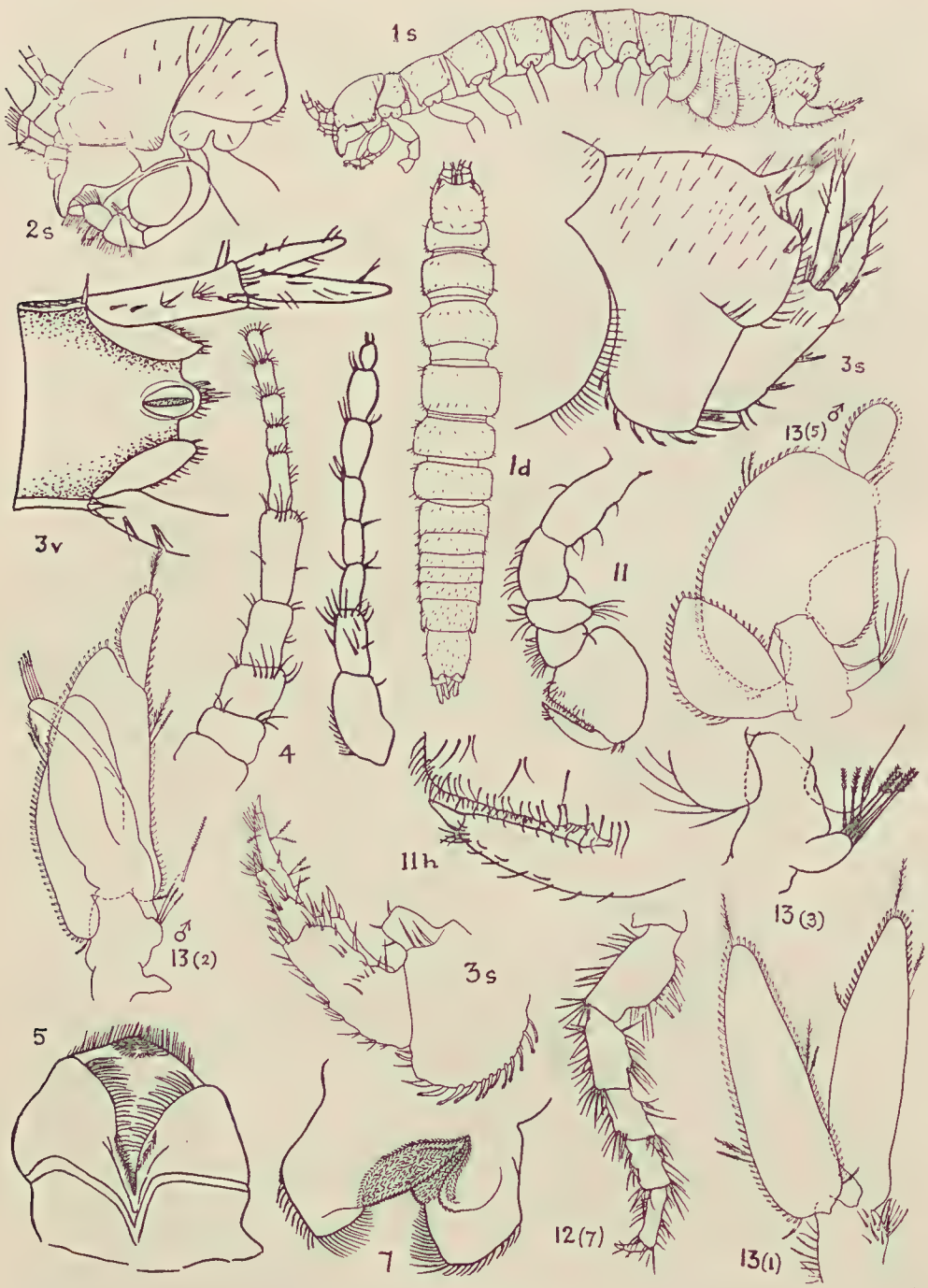


FIG. 43.—*Notamphisopus flavius*, sp. n.

In the *peraeon*, the first segment appears rather shorter, and more expanded ventrally, than in that species, perhaps because its hinder angle is less cut away; generally, setae are fewer and shorter, but in other respects the condition is very nearly that found in *littoralis*.

The pleon is, relatively, rather shorter in *N. flavius*, and its depth slightly greater; a comparison of the *habitus* figures of the two species will reveal other differences, the more noticeable of which are the relative greater length of the first pleon segment, the greater difference in depth between the first and third pleon segments, and in the shape of the several pleura. As seen from the side, the *tailpiece* (fig. 43, *3*) is rather more convex dorsally; the terminal projection appears rather longer and hides the anal prominence, but examined from above it is found that the terminal convexity is relatively less developed and that it is really the short and wide telsonic pleura which conceal the anal prominence; the spines fringing the ventral border of the pleura of the sixth pleon segment vary from twelve to nine in the male and are as few as six in the female; they are stouter and more widely spaced than in *littoralis*. The suture between the sixth pleon segment and the telson forms a distinct ridge armed with three spiniform setae.

Appendages. The *antennule* (fig. 43, *4*) consists, in the male, of eight joints and reaches to a point rather more than halfway along the fifth joint of the peduncle of the antenna. The first joint is large, the second much more slender and quite setose, and the remainder decrease slightly in thickness, except the fourth and fifth, but the appendage is not markedly club-shaped; in the female, there are but four joints in the flagellum. The *antenna* is robust but very short, not reaching to the hinder border of the third peraeon segment. The peduncle is stout, and as in *littoralis*, the joints differ unusually little in relative length; the first and second combined are longer as well as stouter than the fourth; the third and fourth are sub-equal, while the fifth is barely three-fourths of the combined length of the third and fourth joints. The flagellum has but sixteen joints.

The *labrum* (fig. 43, *5*) differs little from that of *littoralis;* it appears narrower, relatively deeper; its lower contour is more regular, but, as in the latter species, the lip has a suggestion of right and left thickened areas. Upon its hinder face a deep V-shaped area is present, the surface of which is covered with setae.

The *left mandible* (fig. 44, *6l*) appears somewhat intermediate in character between that of *littoralis* and *N. benhami*. The *pars incisiva* seems stouter, even, than in the latter, a fourth tooth is barely indicated, while the *lacinia* has but three teeth; the spine row is rather shorter and oval in shape. The hinder border of the appendage is setose, as in *benhami*, but the third joint of the palp has fewer setae.

In the *right mandible* (fig. 44, *6r*) neither fulcral nor acetabular process seems to be as well defined; the primary dentate edge has four stout teeth; at the distal end of the spine row is a small bi-dentate structure which may well be the last vestige of the *lacinia*; its edges are minutely denticulate; the spine row is shorter and narrow, and is followed by a couple of plumose spines, while a more slender, plumose seta springs from the base of the pedicel of the spine row. The third joint of the palp has setae along its whole length set in a double rank. In both palps, the basal joint rises from a rounded elevation.

The *labium* (fig. 43, *7*) differs in no essential from that of *littoralis*.

Maxillula (fig. 44, *8*). The proximal endite is relatively shorter and narrower than that of *littoralis* and, as in that species, there may be but four setospines and two stiff flanking setae. Of four specimens examined for this feature, one

showed an interesting variation in the appendage of one side, there being five setospines in one row and two setose and two slightly pectinate spines in the sub-terminal parallel row, making a total of nine, thus agreeing with the condition observed in some Amphisopine forms and approaching that of *P. orarii*. The third and fourth specimens showed five setospines and two simply pectinated on the proximal endite of one side.

On the distal endite, the stumpy setospine is regularly found but outwardly displaced[1] (i.e., it is nearer to the middle of the row of spines) and, in the more variable specimen, a feebly ciliated seta springs from the posterior face of the inner endite; in other examples, this seta was apparently wanting, but the whole face of the endite is setose, thus agreeing with the condition found in *N. littoralis* and *benhami*.

Maxilla (fig. 44, *9*). The proximal endite is much less incurved mesially than in *littoralis*. The basal lobe projects mesially scarcely at all beyond the edge of the distal part of the endite; its mesial fringe consists of the usual row of filter setae and behind this a rank of about nine pectinate setae. The filter setae end upon the anterior face of the lamella and at that level there is a single isolated spine. The apical setae are loosely pectinate rather than plumose (fig. 44, *9*); upon the outer endite the stiff setae are denticulate, the toothing long and comparatively slender. The anterior face of all of the endites are more or less abundantly setose.

Maxilliped (fig. 44, *10*). This differs in several respects from that of *littoralis*; the epipodite is shorter and rounded, its margin sparsely setose; carpus and propod are less expanded; the coupling setae in *N. flavius* are short, stiff, and barbed—two or three in number and passing by gradual transition into the longer pectinate setae which crown the endite of the basis; the dorsal mesial border of this endite is fringed with plumose (brush) setae which, although restricted to its distal half, are more numerous than in *littoralis*. Moreover, they pass by transition through about three setae into the pectinate spines on the summit of the plate.

Gnathopod (male) (fig. 43, *11*). The ischium is rather longer and distinctly more slender than in *littoralis*, coming nearest in its proportions to that of *P. orarii*. The merus is strongly produced; the propod is sub-triangular, less strong even than in *benhami*, but with palm toothed as in *littoralis*, the dactyl longer and less curved.

The coxae of the *peraeopods* are better furnished with setae than in other New Zealand forms, while the peraeopods are rather less setose than in *littoralis*, except for the bases of the first three which have abundant fringing setae. The propod of the fourth, in the male, is distinctly concave on its posterior border. On the sixth and seventh peraeopods, the flange-like expansion of the bases are, relatively, slightly more pronounced; the penes are long and armed terminally with setae.

Pleopods. The pleopods resemble fairly closely those of *littoralis*; the chief differences are:—

The first pleopod (fig. 43, *13(1)*) has the sympodite less setose; on the endopodite, plumose setae are fewer and along the lateral border of the exopodite there are a few sub-marginal simple setae.

---

[1] It may be that in this species, this setospine is the homologue of the outer of the two occasionally found in *tasmaniae* (see p. 72 below).

FIG. 44.—*Notamphisopus flavius* (8′—apices of maxillulae from other specimens).

In the second pleopod (fig. 43, *13(2)*), the exopodite is relatively wider and the proximal lateral lobe is not nearly so well defined; the penial stylet in one specimen bore only four terminal setae on one side and five on the other, these being minutely pectinate as in *littoralis*. On its inrolled mesial border are three spinules.

The exopodite of the third pleopod is as long as that of the second and distinctly wider, and its fringe of plumose setae extends farther proximally. The third, fourth, and fifth (fig. 43, *13(5)*) are (as in *littoralis*) generally alike, except that the exopodites become progressively wider and shorter; the lobes bearing the entangling setae lengthen and the endopodite of the fifth is much smaller.

The *uropod* (fig. 43, *3s*) differs from that of *littoralis* in several details. The peduncle is, relatively, longer and more slender, and seems less setose along its ventral and lateral surfaces, while its dorsal surface has the inner and outer edges very little raised and with few bordering spines; the inner distal end is produced into a comparatively short process capped by the usual two spines, one equally stout on the distal end of the outer border. The outer ramus is little more than half as long as the peduncle, the inner shorter than the peduncle by one-fourth only of its length. The inner ramus is unusual, however, in bearing half a dozen short plumose setae strikingly like the 'sensory' setae so frequently found on the dactyl of the peraeopods of many Gammarids; these are present, but fewer, in *littoralis*. Beneath the insertion of the rami there is a stout spine, toothed apically, and a much smaller simple spine, in this agreeing exactly with *littoralis*.

Colour. In life, the specimens varied from a uniform golden yellow to reddish orange; in spirit, they quickly changed to a creamy tint while the preserving fluid became bright yellow. This is the only Phreatoicid so far known, whose colouring matter is discharged in alcohol, although the small cadmium-yellow patches on the bodies of living *P. terricola* and *P. longicollis* fade after a few days' storage in spirit.

Size. The largest specimen (male), fully extended, measured 15 mm.

Locality. These were first taken in a tiny creek crossing a road by the Railway Station of Lumsden near the 'Elbow'. The creek was followed northwards through paddocks, and, everywhere, springs were found issuing from a high bank (which seemed to be the face of a river terrace), forming small puddles, from all of which specimens were obtained. Some four weeks later, another visit was made to Lumsden, and the collecting extended to backwaters of the Oreti River, several miles to the north. Here, too, specimens were found, rather paler in colour, but otherwise indistinguishable from those taken in the township.

Notamphisopus benhami, sp. n.

(Figs 45 and 46)

Body (male) compact, sub-cylindrical, distinctly tapering posteriorly, but anteriorly scarcely narrowing. In the peraeon the width is practically uniform, greatest, perhaps, at the seventh peraeon segment where it is approximately one-sixth of the total length; the depth in the peraeon is about four-fifths of the width, the setation much as in *N. littoralis*.

The *head* (fig. 45, *2*) is deeper than long and longer (measured in the mid-dorsal line) than the combined length of the first and second peraeon segments. In both *littoralis* and *flavius* it is slightly less. Its anterior border is shallowly emarginate; it rises in a steep 'forehead' above the well-marked sub-ocular incisure,

the head bulging convexly in the region where, normally, eyes are situated. In this species that area is, most unusually, sparsely set with a cluster of short setae (cf. *M. decipiens* and *Mesamphisopus depressus*). There is a distinct cervical groove and behind this, upon the 'maxilliped segment', is a transverse row of setae, reminiscent of the condition seen in *Mesacanthotelson setosus* and *M. tasmaniae*.

Peraeon. The first segment is exceptionally short, widening below to embrace the head. The second and third segments are sub-equal; the fourth is slightly longer and deeper, its postero-ventral corner produced; the fifth, sixth, and seventh with antero-ventral corner rounded and produced downwardly.

Pleon. The first to third segments are sub-equal in length, with the pleura progressively wider and deeper; the fourth is but slightly longer than the third, but the fifth is nearly as long as the combined length of the first to third; its widened pleuron meets its segment at a sharp angle; the ventral and posterior margin of all the pleura fringed with long, flexible setae.

The tailpiece is a little longer than the fifth pleon segment, dorsally scarcely convex in profile and with no projecting telsonic apex. Examined from above or below, the body is seen to end in a slightly convex border, fringed with setae, behind which the vertical anal opening may be visible (as in *littoralis*). Antero-ventrally, the free border bears eight curved spines (seven in the female); postero-laterally the telsonic pleuron is fringed with plumose setae, while sub-marginally are a spine and a couple of setae. As compared with *littoralis*, this posterior region appears relatively narrower (cf. figs 43 and 45, *3v*).

Appendages. Antennule (fig. 45, *4*). The first joint of the flagellum is quite small, so that it is marked off from the peduncle. The flagellum has five joints (in one specimen only four), the penultimate joint long and swollen.

Antenna (fig. 45, *4*). This appendage, removed, frequently comes away with the corner of the head below the sub-ocular incisure, so that the peduncle seems to have six joints—an appearance frequently suggested in the undissected specimens. The first to third peduncle joints are equally wide, but the third is as long as the first and second combined and as long as, but stouter than, the fourth. The fifth joint is half as long again as the fourth (or three-fourths the combined length of third and fourth), and distinctly more slender; the flagellum, in a male 15 mm. in length, has twenty-six joints and is twice as long as the peduncle.

The *labrum* (fig. 45, *la.*) is robust, as wide as deep; is markedly asymmetrical; the fringing setae are shorter and more uniformly distributed than in *littoralis*. There is a similar depressed V-shaped area bounded by long setae on its hinder face.

Left mandible. As a whole, the body of the mandible, as well as the hinge-like articulation, appears longer than in *littoralis*, the fulcral process more conical, the molar surface more nearly quadrangular and the spine row longer. The opening for the adductor muscle is differently shaped; three or four teeth on the primary dentate edge and three on the *lacinia*.

The *right mandible*, as compared with that of *littoralis*, has the hinged articulation more nearly central, the fulcral process more distinct, bluntly rounded, the hinder (acetabular) region less developed; the *pars incisiva* seems stouter, with three terminal teeth, the fourth antero-lateral and reduced; the spine row long and wider.

In both mandibles, the hinder border of the appendage is fringed with setae and the palps seem stouter and more abundantly setose, the proportion of the joints differing slightly; in the left, both first and third joints are unusually long; the apical fringe of setae in several rows.

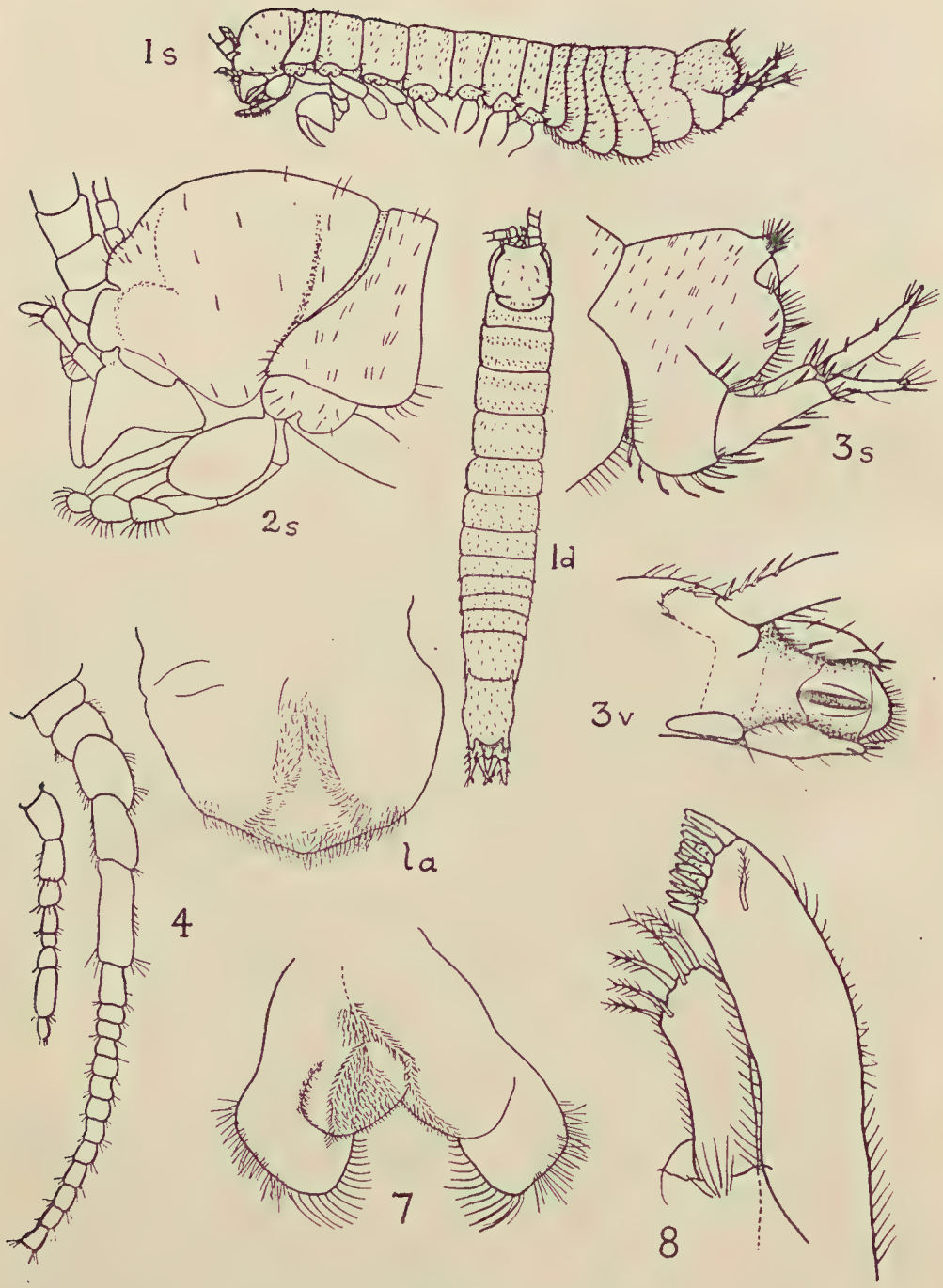


FIG. 45.—*Notamphisopus benhami*, sp. n.

The *labium* (fig. 45, *7*) much as in *littoralis* and *flavius*, but the inner lobe is covered by setules only.

The *maxillula* (fig. 45, *8*) differs from that of most of the other surface-living New Zealand species in normally retaining *five* setospines on the inner endite, the two simple spines lying against the second and fourth setospines; the endite itself being longer and narrower than in *littoralis*. The outer endite has one plumose seta and the usual setospine in the normal position.

The *maxilla* (fig. 46, *9*) resembles closely that of *littoralis*, but the row of filter setae bends more strongly, laterally, onto the face of the inner endite, and an irregular row of stout setae continues this line, while the outer distal endite seems wider and even shorter; the biting setae on both of the distal endites are as numerous as in *flavius*.

The *maxilliped* (fig. 46, *10*) has essentially the condition described for *littoralis*, although there are minor differences in the shape of the epipodite, the relative proportions of coxa and basis; brush setae are more numerous and extend farther proximally along the endite.

In the female, the coxal lobe is large and simple, fringed with fine setae, but bearing, also, about eight very long, flexible setae.

In all the *peraeopods*, the coxa is particularly setose. The *gnathopod* (fig. 46, *11*) (male) differs slightly from that of *littoralis*. The basis is practically bare of setae; the ischium is nearly cylindrical, almost lacking an enlargement of its anterior border; the propod is longer than wide, the palm more oblique, with a gently rounded elevation, not produced into conical teeth at the posterior end of the palm. The dactyl (only about two-thirds the length of the basis) is more curved and bears a series of small setae on its anterior border. The second and third peraeopods are alike.

The fourth peraeopod (fig. 46, *12(4)*) in the male, as compared with that of *littoralis*, is more slender and its propod less widened; the palmar border of the dactyl is minutely denticulate. The remaining peraeopods seem to differ only in minor details of setation from those of *littoralis*; the expansion of the basis in the seventh is perhaps slightly less developed; the hinder border of the dactyl has a fringe of setules; the penis is shorter and does not taper apically.

The *pleopods* resemble fairly closely those of *littoralis*. In the first (fig. 46, *13(1)*), the sympodite has the fringed lateral flange much less developed and less setose; the inner distal entangling setae are few; exopodite and endopodite are sub-equal, lanceolate, but more tapering; the exopodite has very few of the proximal setae simple, almost all being plumose; in the endopodite the setae (nearly all plumose) are fewer, being restricted largely to the distal end, its proximal region being bare of setae.

The outer border of the sympodite of the second pleopod (fig. 46, *13(2)*) lacks setae. The plumose setae on the lateral border of the exopodite extend proximally nearly to the proximal lobe, while the mesial border is thickly fringed with marginal and sub-marginal finely pectinate setae, which are separated distally from the plumose series by a few curiously-jointed setae. The endopodite resembles that of *littoralis*, except that it is rather more reduced; the penial stylet bears three long and two short pectinate setae terminally. The third to fifth pleopods are in general agreement with the corresponding appendages of *littoralis*, the mesial border of the exopodite being free from setae for the proximal half of its length, while more distally the border is thickened and set sub-marginally with simple setae, replaced, near the distal end of the proximal lobe, by a few plumose setae.

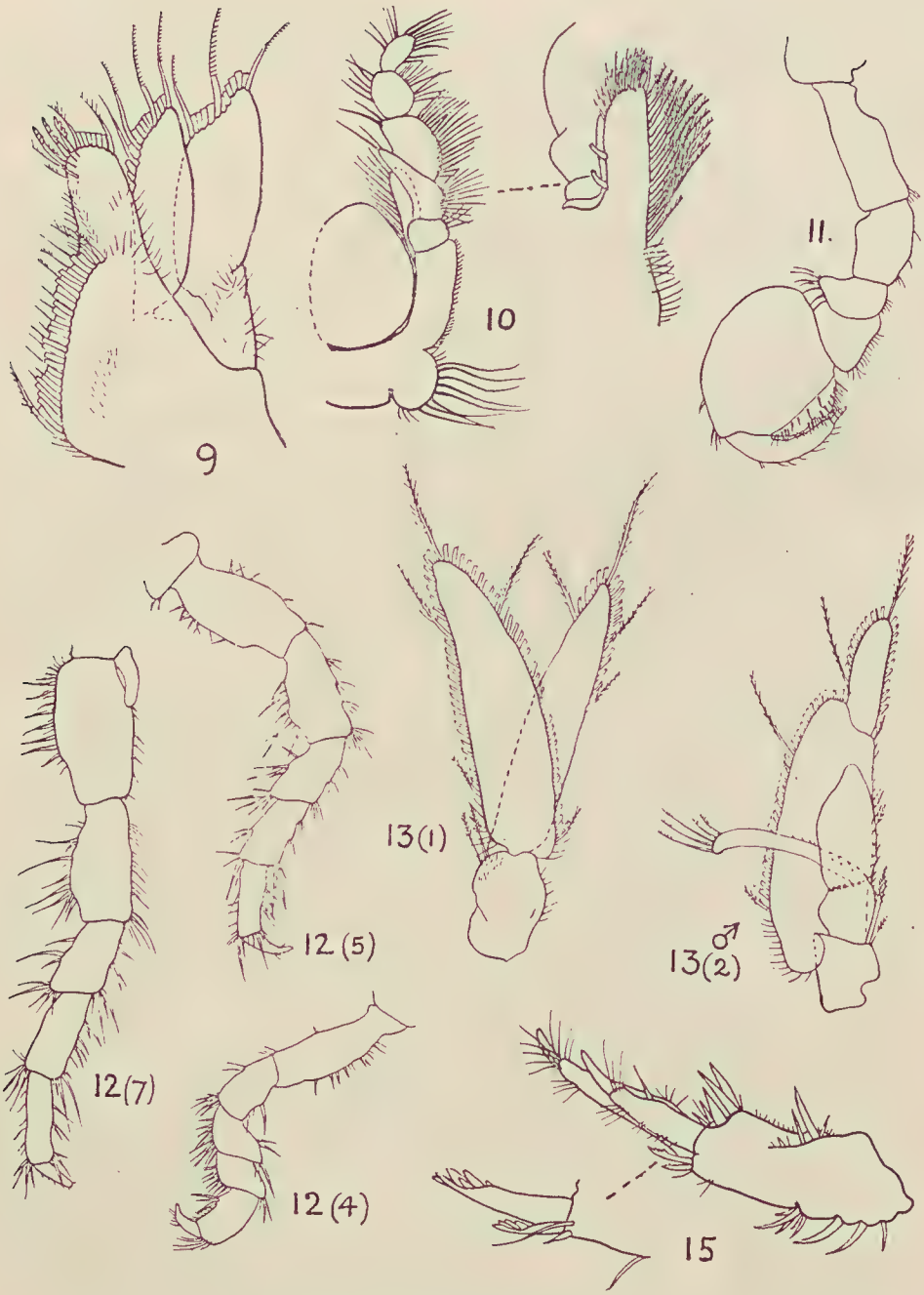


FIG. 46.—*Notamphisopus benhami*, sp. n.

Apart from the minor differences in setation, *benhami* shows differences in the development of the lobes from which arise the entangling setae; and the fourth and fifth pleopods have undergone more reduction in size. In both species the endopodite of the fifth pleopod has an irregular shape.

The *uropods* (fig. 46, *15*) agree generally with those of *littoralis*, but they are rather less spinose. The peduncle shows the dorsal inner edge fringed with short setae but not greatly elevated and ending in a tuft of three stout spines. The outer edge is defined only for about half the length of the peduncle.

The rami are nearly devoid of spines along their length, these being replaced by tufts of setae, but the terminal spines of the rami are relatively much larger and, although fixed, they are clearly marked off from the rami. There are *two* toothed spines, one much stronger than the other, beneath the insertion of the rami, differing in this from both *littoralis* and *flavius*, but agreeing with *N. dunedinensis*.

Colour. In life, a pale yellowish or greenish grey; in spirit, fading to straw colour.

Size. The largest males about 15 mm.

Locality. Under moss and debris along the bed of a tiny creek, flowing through extremely dense tree-fern scrub and discharging into Horseshoe Bay on the eastern shore of Stewart Island. Several specimens were taken at the actual outlet, a few feet only above high-water mark, where the creek opens out to discharge across the sand into the sea. They were associated with a freshwater Idotheid *Austridotea* sp.

Notamphisopus kirkii (Chilton)

(Fig. 47)

Chilton, 1906, p. 274 *(Phreatoicus kirkii).*
Sheppard, 1927, p. 110 *(Phreatoicus kirkii).*

Chilton's description of this species is very brief and vague, being limited to an incomplete comparison with *Neophreatoicus assimilis* which is, itself, the least typical of Southland (New Zealand) forms.

Of specimens from the type locality (a lagoon in the Island of Ruapuke) no specimens were available until quite recently. Indeed, Part I of this paper had been sent to press when there were received from Professor Perceval some half-dozen specimens. Previously Dr. Chilton had supplied two specimens (male and female) taken at Drummond, tentatively referred to *kirkii*.

A comparison of preparations made from these with others dissected from the Ruapuke material revealed numerous differences, sufficiently marked to make it necessary to refer the Drummond material to a new species, which is described later under the name *N. percevali* sp. n.

The accompanying description of *kirkii* is an amplification of Chilton's account.

Body sub-cylindrical (fig. 47, *1, s.*), scarcely fusiform, appearing more robust than *benhami*; it is widest at the third peraeon segment. In the male, the body tapers slightly in the pleon, the tailpiece being barely two-thirds of the width of the peraeon; the total length is approximately seven times the width. In the mature female these proportions are rather different, the width of the tailpiece being less than three-fifths of that of the third peraeon segment, and the total length scarcely five times as great as the width. The surface is smooth except for short and sparsely scattered fine setae.[1]

[1] Not represented in the figures of the female, (47, *1s* ♀, *1d* ♀).

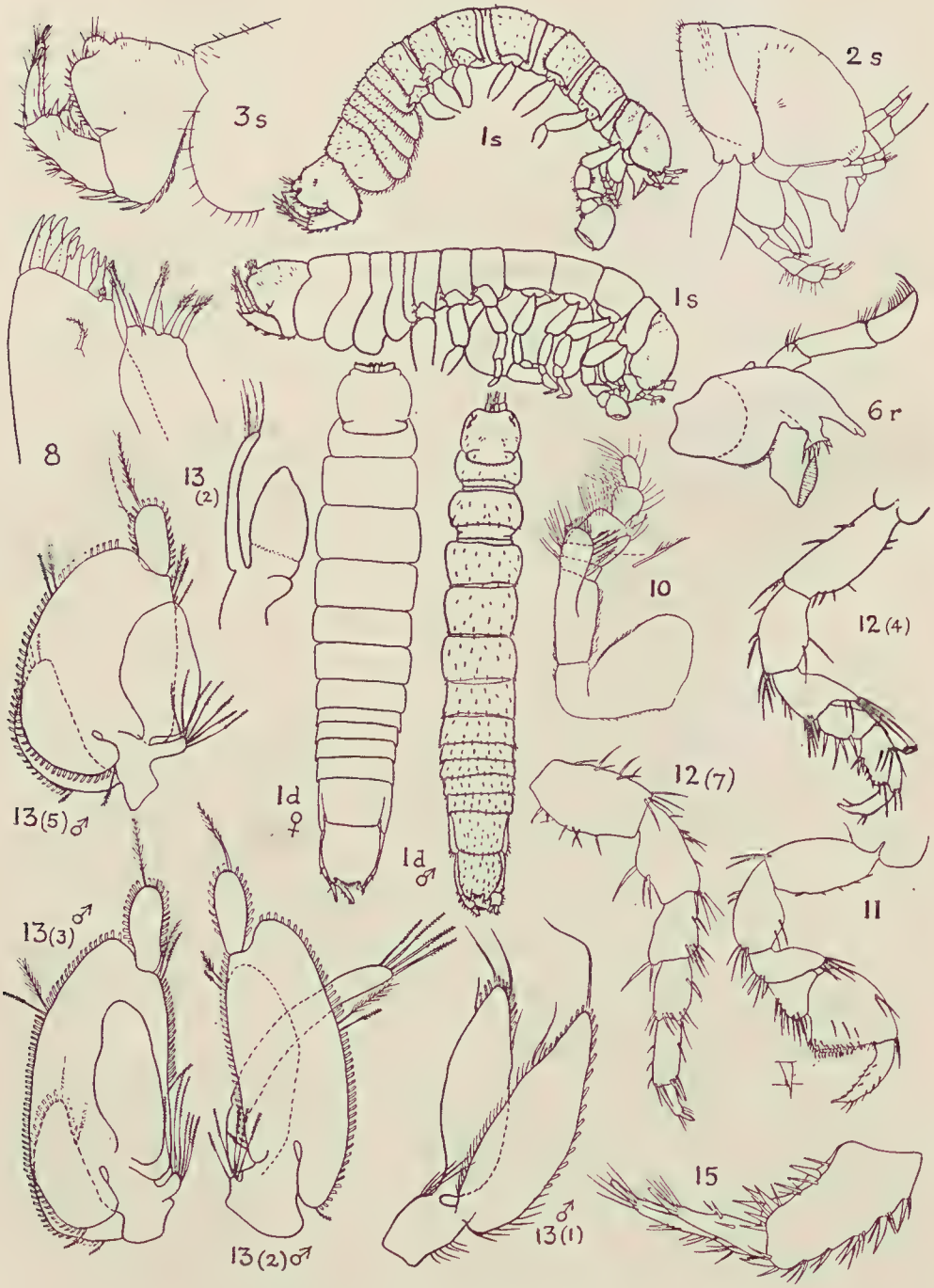


FIG. 47.—*Notamphisopus kirkii* (Chilton).

The *head* (fig. 47, *2*) agrees quite closely with that of *littoralis*, the frontal slope perhaps a little less steep, and there seems to be no trace of a 'posterior process'; the shape of the mandible as seen in position, also, differs slightly.

In the *peraeon* the first segment is deeper and, although directed forwardly, is not notably expanded ventrally; the related coxa is ill-defined. All of the peraeon segments are fringed along the entire posterior margins with fine setae. Chilton's note that the segments of the peraeon fit closely to one another refers to the contracted state. As is shown in the figure (fig. 47, *1s*, *1d*♂) of a partly relaxed specimen, the segments may separate in this as in other New Zealand species.

In the *pleon*, the pleura appear less widened than in *littoralis* or *benhami*, and the posterior margins are more setose. The *tailpiece* is scarcely longer than the fifth pleon segment; the terminal convexity is narrower than in *benhami*, and the telsonic pleura are less developed.

The ventral border of the pleura of the sixth pleon segment (anterior to the insertion of the uropod) seems narrower and the armature of spines more close-set and may bear six or seven spine-setae; the suture, above the uropod, between the telson and the sixth segment, is short and bears but a single spine. The anal opening is directed postero-ventrally. Chilton states that, in side view, the telsonic projection is narrower than in *N. assimilis*. Actually, as seen in dorsal view, the two tailpieces are quite unlike.

Appendages. Antennule and *antenna* do not differ in any noteworthy respect from those of *littoralis*. The *mandibles* (fig. 47, *6*) are in general agreement with those of *benhami*; the inner surface behind the molar, on the right mandible at least, is unusually setose.

The *maxillula* (fig. 47, *8*) has but four setospines on the inner endite; the sub-marginal spines are slender and simple, standing against the second and third setospines; the outer endite is normal, with about ten spines, some denticulate, and one small setospine; there is, also, one plumose seta on the posterior face of the endite.

The *maxilla* appears to be normal, excepting, perhaps, that the number of spine-setae upon the apex of the proximal endite is small and the setae (which are coarsely denticulate on the lateral border) are rather unusually stout.

The *maxilliped* (fig. 47, *10*) differs in several details; the coxa is relatively shorter; the endite on the basis is less produced and has relatively few (seven to eight) brush setae which are ciliated on the distal side only, and are restricted to the distal half of the endite.

The *gnathopod* (fig. 47, *11*) differs from that of *littoralis* in shape and armature of its joints, notably in the shape of the propod; the fourth peraeopod of the male (fig. 47, *12(4)*), also, differs in some of the joints, the merus being strongly produced antero-distally, the propod with its posterior border convex; the succeeding limbs are less setose than those of *littoralis*.

The *pleopods*, too, show several differences. The first pleopod of the male (fig. 47, *13(1)*) has the lamellae ovate rather than lanceolate; on the exopodite the plumose setae are much less numerous, extending on the mesial border only along the distal third of its length. Both lamellae rise from narrow stalks, particularly the endopodite, which retains a few plumose setae apically.(1) The second pleopod, too, bears upon the exopodite comparatively few plumose setae

(1) Nevertheless, in the occurrence of setae upon the endopodite of this pleopod there was a marked difference, not only from *dunedinensis*, but from all Phreatoicids known at that time (with the exception of *Hypsimetopus*), and it is surprising that Chilton did not call attention to this character.

(fig. 47, *13(2)*); its endopodite as compared with its related exopodite appears much shorter; it is clearly marked into two regions; the rather long penial filament has four (or five) terminal setae.

In the remaining pleopods the exopodite becomes increasingly longer relatively to the endopodite, which is, however, less reduced than in *littoralis*; the epipodites are longer and narrower. The lobes bearing the entangling setae are well developed.

The *uropods* (fig. 47, *15*) do not differ essentially from those of *littoralis*, but they appear rather more spinose; beneath the insertion of the rami there is, beside the stout toothed spine, a smaller spine, also toothed, this apparently replacing the small simple spine found in this situation on *littoralis* and *flavius*.

Colour. Whitish (in spirit).

Length. 17·5 mm. (Chilton, 1906, p. 275).

Habitat. A fresh-water lagoon on Ruapuke Island.

Notamphisopus percevali, sp. n.

(Fig. 48)

The material available for study consisted of two specimens (male and female), collected by Professor Chilton at Drummond, and as noted above, tentatively assigned by him to *kirkii*. They prove, however, to be distinct from that species, and are apparently intermediate between *dunedinensis* and *benhami*. Unfortunately, both of the two specimens were temporarily mislaid, so that the description is limited to appendages which had been removed and mounted, and to notes made at the time of dissection, when the specimens were accepted as examples of *N. kirkii*.

Antennule (fig. 48, *4*). In the female this is short, seven-jointed, with practically no distinction between peduncle and flagellum; in the male there are eight joints and the appendage is longer than the peduncle of the antenna. This latter appendage is about three times the length of the antennule, its peduncle robust, the flagellum with sixteen joints.

The *labrum* is stout, slightly asymmetrical.

Left mandible. Dentate edge with four teeth, *lacinia mobilis* with three. On the right mandible, also, there are four teeth on the primary dentate edge; the spine row is markedly setose; the molar notably oblique, the palp with long second joint, setae on the third joint are restricted to the distal half, as in other species of *Notamphisopus*. The *lower lip* (fig. 48, *7*) shows but one setospine in the dense fringe of simple setae.

The *maxillula* (fig. 48, *8*) resembles that of *dunedinensis* and differs from that of *assimilis* in that the simple spines on the inner endite lie against the second and third setospines instead of the rather unusual condition occurring in *assimilis*, where the simple spines lie mesially against the third and fourth of these. In all three of these species, there is but one sub-terminal plumose seta (in this species almost a simple seta) on the posterior face of the outer endite, which bears twelve apical spines, some denticulate, and a short setospine.

In the *maxilla* (fig. 48, *9*), the inner of the two endites of the third segment is shorter than the proximal endite. The basal part of this latter appears as a wide triangular region fringed, as usual, anteriorly by close-set filter setae and a posterior row of biting setae, of which, however, there are only about eight (much as in *kirkii*); the distal part of the endite is short and fringed its whole length with simple hair-like setae. The apex bears mixed plumose and pectinate setae.

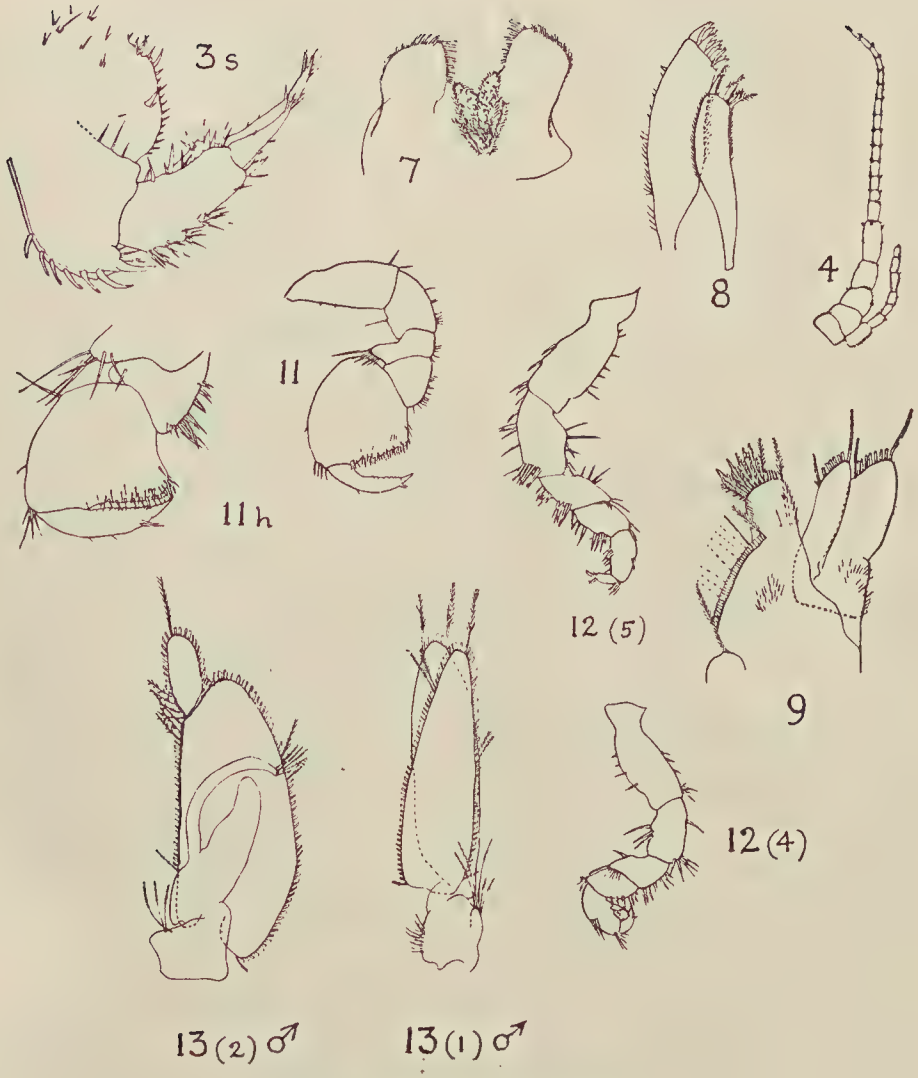


FIG. 48.—*Notamphisopus percevali*, sp. n.

The *maxilliped* has a very elongated coxa, the sub-oval epipodite being setose mesio-proximally. The endite is armed apically with a short row of stout biting setae and its dorso-mesial border bears some seven or eight brush setae; the propod is sub-circular, the moderately long dactyl bearing setae only on its mesial edge. In the female, which shows immature brood lamellae, the coxal lobe of the maxilliped is very feebly developed; the epipodite is sub-ovate.

The *gnathopod* of the male (fig. 48, *11♂*) seems to differ slightly from that of *dunedinensis* in the armature of the palm. In the female (fig. 48, *11h*) the merus is produced anteriorly and bears a tuft of setae as recorded by Chilton for *assimilis*; the whole limb is much less robust than that of the male.

The *fourth peraeopod* (fig. 48, *12(4)*) is sexually modified in the male, but is not appreciably shorter than the third, whereas in *assimilis* this appendage is distinctly shortened; the armature of the palm differs in minor details from that of *dunedinensis*.

In the degree of expansion of the bases of the fifth to seventh peraeopods, there is also a small difference from the condition of *dunedinensis*.

It is in the condition of the *pleopods*, however, that this species, like *kirkii*, differs markedly from *dunedinensis*. The first pleopod (fig. 48, *13(1)*) has an endopodite sub-equal and similar to the exopodite, both lamellae being setose. The endopodite has an apical series of about eight feebly plumed setae. It has thus the least setose condition of any of the Southland forms, excepting *dunedinensis*. The sympodite has about five entangling setae (fewer in the female), while upon the lateral border are six or seven setae.

In the succeeding pleopods, the mesial border of the exopodite is armed along almost its entire length with short, pectinate setae. In the male, the penial stylet on the second pleopod (fig. 48, *13(2)*) is very strongly curved and armed with a terminal series of six or seven stout setae.

The sixth pleon segment has the ventral border armed with seven spines, the last, immediately beneath the insertion of the uropod, being very stout, the six preceding curved, apically toothed, and much more slender.

The telsonic pleuron is fringed with spinules with one or two much stouter spines. One spine is just sub-marginal, while three slender spines arm the suture between the sixth pleon segment and the telson.

The *uropod* is short and stout, its inner dorsal border slightly raised distally to end in a stout spine. Both inner and outer borders are spinose and the ventral edge has four tufts of mixed spines and setae. Apically beneath the insertion of the outer ramus is a stout spine, toothed at its end. The inner ramus is slender and gently tapering, rather shorter than the peduncle, with a few spines and setae, the outer ramus, only half the length of the peduncle, very slightly setose.

Colour. Whitish, in spirit.

Occurrence. At Drummond, in Southern Otago.

Among Chilton's notes were found records of the distribution, etc., of this species. Numerous specimens were said to have been taken (Jan., 1907) in a pond at Drummond in mud at roots of rushes, etc.; white in colour, blind and rather sluggish. A little later a few small specimens were taken in cleaner water on Elodea, Microphyllum, etc., presumably also at Drummond. Another collection (23.12.22) of about 8-10 specimens is recorded from 'Ringway', Drummond. A single male was found (5.1.14) on roots of rushes in the creek at Redfern 'Otautau'; specimens were also noted from a creek near Invercargill. This is presumably the collection found in a tube labelled 'Creek, Otatava Rd., Invercargill' and comprising five small, compact animals, dark in colour.

Notamphisopus dunedinensis (Chilton)

(Figs 49 and 50)

Chilton, 1906, p. 275 *(Phreatoicus kirkii,* var. *dunedinensis).*
Sheppard, 1927, p. 111 *(Phreatoicus kirkii,* var. *dunedinensis).*

This form which was originally recorded as a variety only of *Phreatoicus kirkii,* actually differs very markedly not only from that species, but from all other Southland forms; it is undoubtedly a distinct species. Chilton's account is so very brief and chiefly in terms of comparison with *kirkii* that a full description is necessary.

Body fusiform, sub-cylindrical (fig. 49, *1*); the width, which equals the greatest depth in the pleon, remains practically uniform from the third peraeon to the third pleon segment, narrowing slightly at both ends. Its length is six times its maximum width.

Head (male). Seen from above (fig. 49, *1d*), it is sub-circular, width and length being equal, and its length being equal to that of the second peraeon segment which is, also, that of the greatest depth of the head. In the female, the width, relatively, is slightly greater than the length of the second or even of the third peraeon segment. The anterior border is very shallowly emarginate; a short but quite definite cervical groove rises, rather high up, from the posterior border of the head.

Peraeon. This region appears rather longer than in most surface-living New Zealand forms, being practically twice the length of the pleon. All the segments have the bevelled margin, and all are fringed with sub-marginal setae along their entire posterior border. The first segment is short, less than half the length of the second and shorter even than the seventh. In the male, it widens markedly below, while in the female, though less expanded, it still overlaps the hinder border of the head, to which it appears immovably attached. The second to fifth segments are sub-equal, the third being just a little the longest; the sixth and seventh are each considerably shorter than the segments preceding them. The first four segments are scarcely hollowed ventrally for the coxa, but the fifth, sixth, and seventh are deeply excavate and each is strongly downwardly produced in front. In a female, with brood-pouch, the coxae of the anterior group of legs actually project slightly outwardly.

Pleon. The first four segments are sub-equal, the fifth as long as (female) or a little longer than (male) the combined length of the third and fourth. The pleura are fringed ventrally and posteriorly with long, flexible setae, the pleopods hanging well below them. The *tailpiece* is a little longer than the fifth segment. The telsonic apex—broad and strongly convex, armed with several (about eight) spines dorsally and a fringe of several setae terminally—is scarcely upturned; the pleura, which do not project behind the telsonic apex, are separated by an incisure on either side and quite distinctly developed, and are fringed with spinules or stout setae and one sub-marginal spine. In dorsal view, this shows far greater resemblance to the condition seen in *Paramphisopus* spp. than it does to that of *N. assimilis.* Antero-ventrally, the border of the sixth pleon pleuron bears five to seven curved spines, the last one or two stout and simple, the more anterior finely toothed apically. The ventral suture between the sixth pleon segment and the telson rises some little distance dorsally to the uropod and bears three or four fine curved setae. The anal opening lies anterior to the telsonic apex and is presented postero-ventrally.

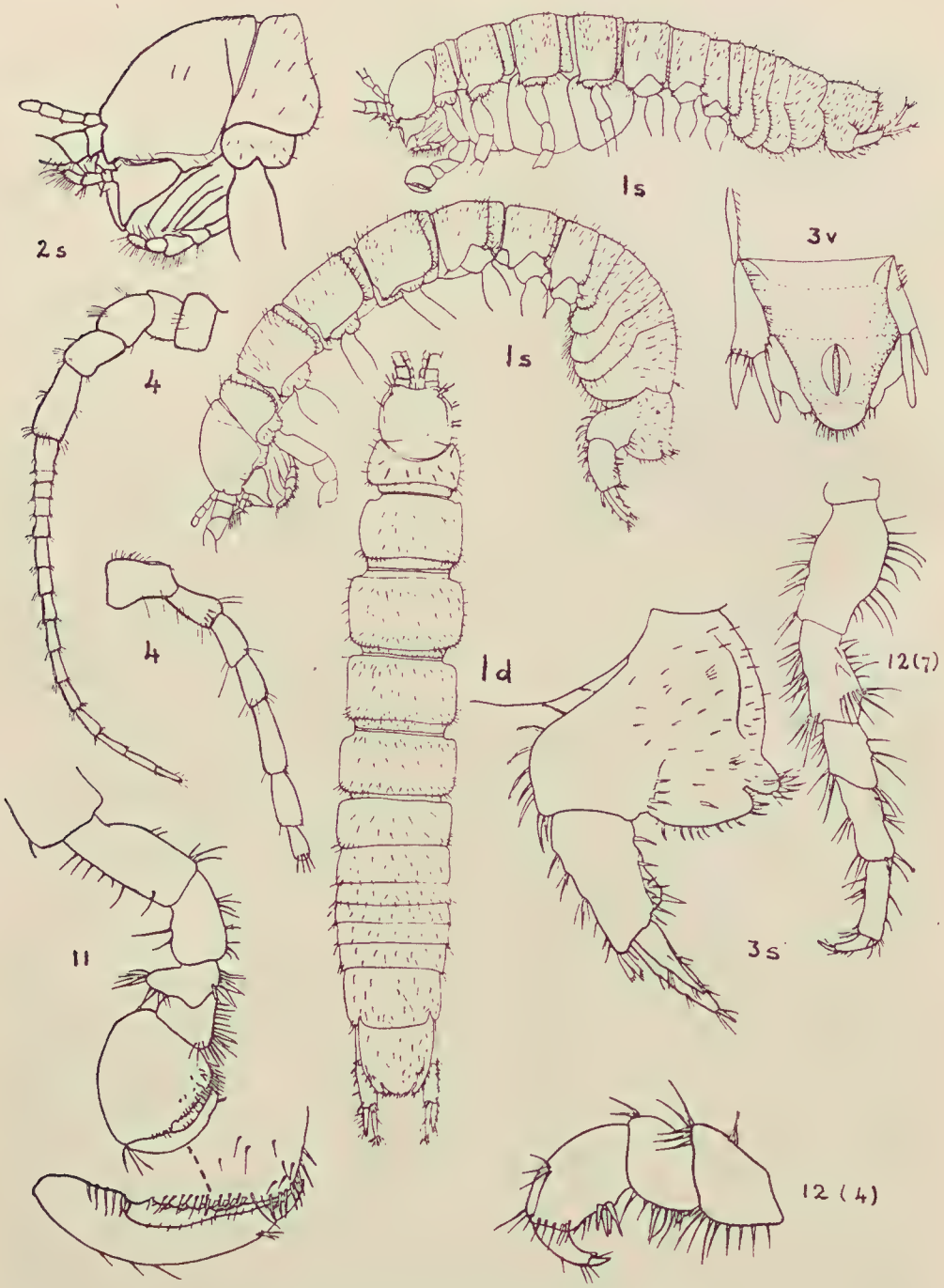


FIG. 49.—*Notamphisopus dunedinensis* (Chilton).

Appendages. The *antennule* (fig. 49, *4*) is as long as the peduncle of the antenna, with seven joints in the male and six in the female; there is little distinction between peduncle and flagellum, the first and second joints of the flagellum being long and scarcely swollen. The *antenna* is short, peduncle joints decreasing in stoutness but not increasing greatly in length, except the fifth which is once and a half the length of the fourth. The flagellum, with fifteen to eighteen joints, is not twice as long as the peduncle.

Mouth parts. Labrum (fig. 50, *5*) very wide and shallow, strongly asymmetrical, only the middle third of its border fringed with setae; its hinder surface with a V-shaped setose area.

Mandibles. Right (fig. 50, *6r*). Dentate edge with four strong teeth, spine row strong, molar stout, oblique; palp short and stout; second joint twice as long as first, third joint three-quarters of the length of the second, fringed on the distal part of the upper border with curved, finely pectinate setae; these in the apical half appear to lie in at least two rows (cf. *Mesacanthotelson*). In the left *mandible*, the principal cutting edge has the usual four teeth, the *lacinia* is strong and bears three teeth; there is a dense fringe of setae at the base of the molar; in the palp the setal armature of the third joint is less developed.

Labium, as in *littoralis*.

Maxillula (fig. 50, *8*). Inner endite short, narrow, truncate apically, bearing four setospines and two slender simple spines, feebly ciliated, lying between first and second, and second and third. The outer endite has eleven spines and one setospine; there is a single plumose seta on its posterior face.

Maxilla (fig. 50, *9*). The basal and distal mesial edges of the proximal endite meet at an angle, but the distal lobe is not curved mesially inwards as in some Southland species. The row of filter setae is carried round onto the anterior face of the joint, and, as in *percevali* and *kirkii*, there is a stout spine external to its upper outer end. The pectinate setae are few (eight) in number. The two outer endites, though short, are relatively long as compared with the proximal endite and the outermost is much wider. The setae arming the lobes are as in *littoralis*.

Maxilliped (fig. 50, *10*). The coxa is shorter (relatively to the basis), the epipodite long. The two coupling hooks which stand out very distinctly from the other setae on the endite are stout, curved, and apically toothed; on the mesiodorsal border of the endite, the proximal part is occupied by a close fringe of simple setae; distally there are about eight or nine brush setae; these, as in all species of *Notamphisopus* are ciliate on the distal side only.

In all the *peraeopods*, the coxae are setose. The *gnathopod* (fig. 49. *11*) has a stout propod, with the anterior border very convex, the greatest width and length sub-equal, the posterior border short, the slightly convex palm armed with stout conical teeth and an outer fringe of spiniform setae which are continued from the palm onto the posterior border; the condition of the palm differs from that of *kirkii* in both female and male.

The second to fourth peraeopods are much alike, the last being shortest and more evidently sub-chelate (fig. 49, *12(4)*), a group of four spines being placed to receive the tip of the curved and shortened dactyl; it is even less modified than in the case in *kirkii*. The fifth, sixth, and seventh are progressively longer and stouter and increasingly setose (almost spinose), the basis little expanded but, nevertheless, stouter and wider relatively than in specimens of *percevali*. Chilton has noted that the basis is *less* expanded in *dunedinensis* than in *kirkii*.

It is in the condition of the *pleopods*, however, that *dunedinensis* is most sharply marked off from all other Southland species, the endopodite being without setae and generally unlike the exopodite in shape and markedly smaller.

The *first pleopod* (fig. 50, *13(1)*) has the sympodite stout and squarish with a few short setae laterally but no expanded lateral flange; from its inner border arise numerous entangling setae; the exopodite broadly lanceolate, blunt-ended, three-fourths of its outer margin bearing plumose setae, the proximal fourth fringed with simple setae; the proximal half of the inner border is edged with stiff pectinate setae, both marginal and slightly sub-marginal; the apical half is for the most part composed of plumose setae. The endopodite is sub-oval, much shorter than the exopodite, but its basal region is unusually long, suggesting an oblong proximal joint; it may be notched apically.

Upon the sympodite of the *second pleopod* (fig. 50, *13(2)*), the entangling setae spring from a projecting lobe; on the exopodite plumose setae are restricted to the distal lobe and the outer half of the proximal lobe, while on the inner border simple (some pectinate) setae fringe almost the entire length of the proximal lobe. The endopodite is longer, reaching to the base of the distal lobe; the penial stylet is long and curved, armed terminally with four stout setae.

The *third pleopod* (fig. 50, *13(3)*) differs from the second (apart from the sexual modification of the latter) in a much increased width, and, of course, in the presence of an epipodite; the inner fringe of setae on the exopodite arms only the distal two-thirds and tends to spread considerably inward from the margin; the fourth and fifth show a decrease in length, and the fifth is markedly wider; the endopodites, too, are relatively smaller, while the lobe on the sympodite bearing the entangling setae becomes more elongated mesially. The pleuron of the fifth pleon segment differs from that of *percevali* (and of *kirkii*) in that it has setae scattered over its surface as well as forming a fringe.

The *uropod* is comparatively stout and short. The length of the peduncle is less than twice its depth at its insertion; its inner dorsal edge is markedly raised, its ventral border less strongly armed and there are but one or two spines on its lateral surface. The joint is markedly less spinose than in *kirkii*. The rami are short and feebly setose, while beneath their insertion are two almost equally strong spines, toothed apically.

Size. Up to 22·5 mm., female with brood-pouch 13 mm.

Colour. Whitish.

Occurrence. From streams at Mosgiel and at Woodhaugh (near Dunedin).

It would be tempting to suppose that we have in these southern New Zealand species a series of surface-water forms passing into subterranean forms with progressive reduction of the pleopods. In *Notamphisopus* these retain a more nearly primitive condition, but showing a steady decrease in setosity (or in increasing departure from the natatory condition) from *littoralis* (through *benhami*, *flavius*, *kirkii*) to *dunedinensis*. In the lastnamed the endopodite of the first pleopod has become seta-less and the exopodite shows a marked diminution in the number of plumose setae. In *assimilis*, the difference in size of the exopodite and endopodite is still more marked, and the exopodites also nearly devoid of plumose setae, the reduction reaching a climax in *P. typicus* and *P. orarii* with the pleopods short and oval (rather than lanceolate) and still less setose (or even bare), and the obsolescence of the endopodite a stage more advanced.

But, in the condition of its mouth parts, particularly the maxillulae and maxillae, *typicus* is so much the more primitive, that its derivation from known surface-water New Zealand forms is precluded. The fact that in *littoralis* and in

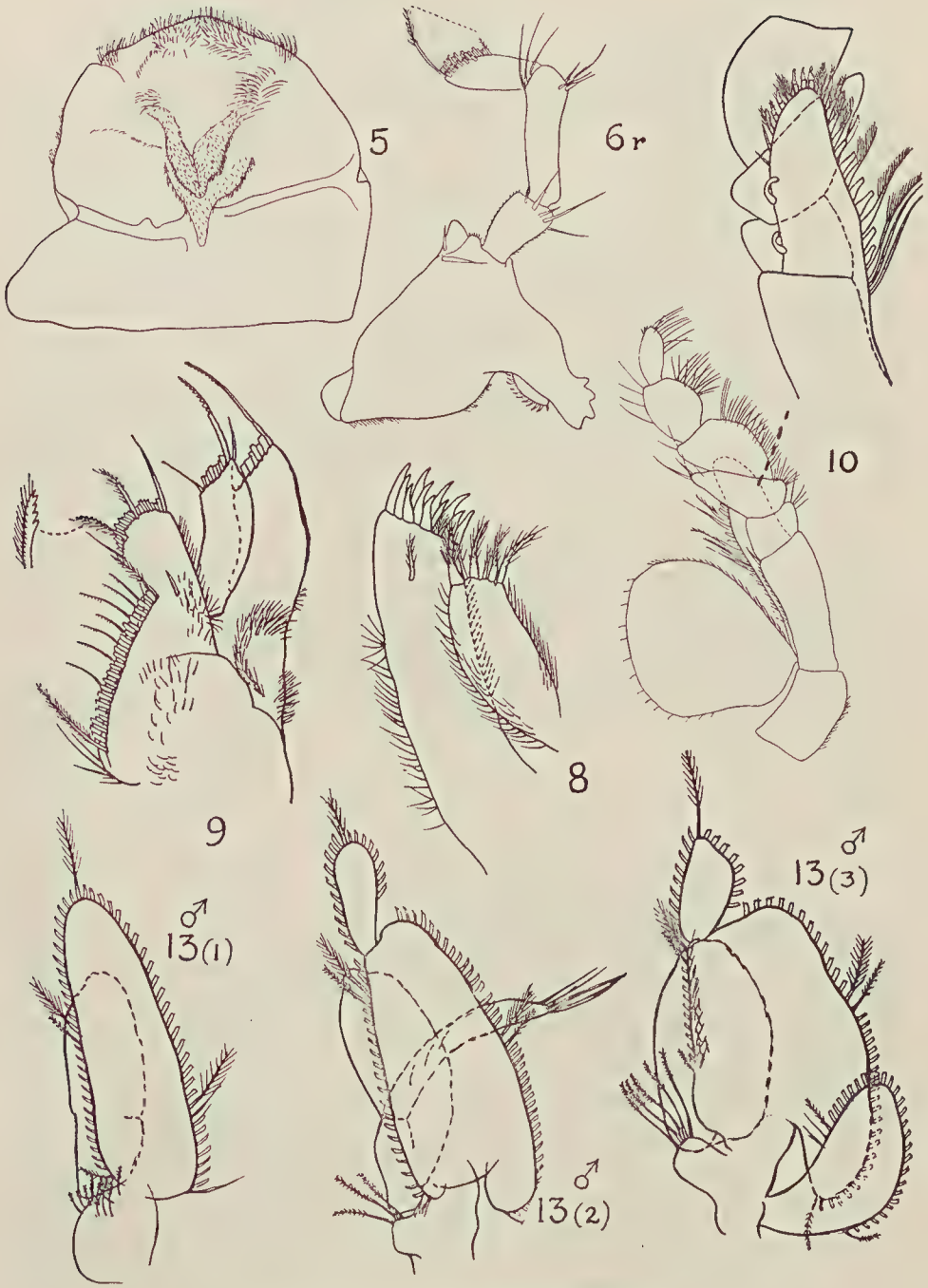


FIG. 50.—*Notamphisopus dunedinensis* (Chilton).

flavius, however, the condition in the maxillula may variably approach that of *typicus* suggests that they had a not-too-remote common ancestor with both mouth parts and pleopods unreduced.

The small bifid structure at the ventral end of the spine row of the right mandible of *flavius* may be a persisting vestige in this genus of that *lacinia mobilis*. A similar structure has been seen in one specimen of *P. orarii*.

The obsolescence or the absence of the posterior process of the head is another feature common to all New Zealand species.

The *Notamphisopus* species show, in certain features, a strong likeness to *M. setosus*—a likeness perhaps most evident in *dunedinensis*, although in the latter species the head is narrower, probably due to the decreased size of the brain, resulting from the loss of the eyes in the New Zealand forms. A resemblance to *assimilis*, which Chilton stresses, is much less evident, the vermiform body of the latter pointing to a prolonged subterranean existence.

On the tailpiece, the telsonic apex has spines dorsally—instead of posteriorly as in *Paraphreatoicus* and *Metaphreatoicus*. The shape of the apex is reminiscent of that found in some Amphisopine forms, like that, too, in the shortened condition, and because of that shortening the telsonic pleura appear similarly more produced backwardly.

The sixth pleon pleuron agrees with that of *Onchotelson* and *Metaphreatoicus* in its armature of relatively numerous spines, many of them terminally toothed; the suture above the uropod insertion resembles that of the Tasmanian species, *setosus*, but the uropod of *dunedinensis*, like that of *tasmaniae*, shows the end of the peduncle armed with two stout, toothed spines, in this agreeing, also, with *benhami* and *kirkii*; in *littoralis*, *flavius*, *setosus*, and *brevicaudatus*, there is but a single, toothed spine accompanied by a smaller simple spine, while in the species of *Phreatoicus* and *Neophreatoicus* both of these spines are simple.

Sub-family VII. MESACANTHOTELSONINAE

Body fusiform, rugose; head with well-marked cervical groove; eyes prominent, with many facets; first peraeon segment free or fused with head; peraeon subcylindrical, segments generally deeper than long, with transverse bands of spines or setae; pleon slightly compressed, the incomplete suture between sixth pleon segment and telson marked by a short line of spines or stiff setae; tailpiece with well developed telsonic projection.

Antennule of moderate length, not swollen apically; *lacinia mobilis* on left mandible only; maxillula usually with five or fewer setospines on inner endite; coxae of sixth and seventh peraeopods produced posteriorly; basis and ischium of peraeopods not expanded, ischium relatively long; fourth peraeopod of male subchelate; sympodite of pleopods with numerous entangling setae; epipodites moderately large; penial stylet curved, elongate, strongly armed terminally; spine beneath the insertion of the rami at the end of the peduncle of the uropod toothed; apex of rami sharply-pointed.

Three genera, *Mesacanthotelson* gen. n., *Onchotelson* gen. n., and *Colacanthotelson* gen. n.

Mesacanthotelson, gen. n.

Body with segments strongly rugose; head with shallow anterior emargination and with the cervical groove complete or interrupted dorsally; eyes large, prominent, not forming part of the profile of head; pleura of sixth pleon segment armed with a few spines; telson long with sub-cylindrical projection, little upturned, armed along its length and terminally with spines and setae; the third joint of the mandibular palp armed with a brush of setae; median process between maxillipeds; uropods long.

Genotype. *Mesacanthotelson setosus*, sp. n.

This genus has been instituted for four (or possibly five) species, all from the Great Lake, Tasmania; in normal circumstances G. M. Thomson's species, *tasmaniae*, which was the first to be recorded, would have been named as type species. From a comparison of the figures, it could well be identical with Geoffrey Smith's form *spinosus*. But both Smith's and Thomson's descriptions are sadly inadequate; they are, for instance, useless in discriminating between *tasmaniae* and *fallax*. Miss Sheppard, who examined specimens collected by Smith, is satisfied of the identity of that author's '*spinosus*' with Thomson's *tasmaniae*. The present writer, also, has had two specimens (both half-grown) of Smith's material for examination, and these agreed sufficiently well with Thomson's figures to justify acceptance of Miss Sheppard's conclusion.

Thomson had, however, but a few examples, preserved dry, and said to be mutilated, and apparently his type is not now available. Also, it seems certain that his material from the Great Lake included at least two different species, for he notes[1] that 'the young (small specimens presumably) of *P. tasmaniae* resemble the adult form of *P. australis*', a statement which is, in fact, quite incorrect. It seems entirely probable that these 'young' were immature specimens of another species, perhaps *chiltoni* Sheppard (= *australis* G. Smith), for in this same paper Thomson transfers to *tasmaniae* specimens taken earlier on Mt. Wellington (Jan., 1892) which he had originally assigned to *australis* Chilton. These latter may be confidently accepted as examples of the species *thomsoni* described below, for *tasmaniae* is not known from any waters other than those of the Great Lake, nor is any Phreatoicid other than *thomsoni* known from Mt. Wellington.

As to Smith's material, it seems not at all improbable that his collection of '*spinosus*' may likewise have been a mixed one in which two species were represented. With regard to the size of their species, the two authors differ markedly, Thomson's specimen being recorded as a little over half an inch, while Smith's specimens attained almost to an inch. At the present time several species are known, of which both *fallax* and *decipiens* are relatively small; *setosus* approaches *tasmaniae* in size, but it largely lacks *spines*. While, therefore, Miss Sheppard's identification of *spinosus* with *tasmaniae* (G.M.T.) may be accepted as probably correct, it is not completely convincing.[2] Accordingly, with the desire of avoiding, if possible, further nomenclatorial confusion, the new species *setosus* has been selected as the type of this genus, although in as far as the telsonic projection is concerned, it is perhaps not the most primitive, for it seems possible that that structure in *setosus* has been derived by reduction from the condition still retained by *tasmaniae*. It occupies, however, in many respects a rather central position in the genus, and in many of its characters it links up with the surface-water New Zealand forms and possibly, also, with *Onchotelson*.

---

(1) 1894, p. 349.

(2) Barnard (1914, p. 232) had previously pointed out that *spinosus* might be a 'larger form of *P. tasmaniae*, though the fifth pleon segments differ'.

Mesacanthotelson setosus, sp. n.

(Figs 51 and 52)

Near to *M. tasmaniae*, which, except for its lesser spininess, it resembles so closely that a superficial examination might confuse the two. Like *tasmaniae*, its length is six and a half times its greatest width. Under close scrutiny it is found to differ from the Great Lake species in numerous details.

The surface of the body is strongly ridged, but stout setae for the most part take, somewhat variably, the place of spines; upon the head, however, even setae are almost wanting, and in both the 'maxilliped segment' and the first peraeon segment, the single transverse row of spines, found in *tasmaniae*, is, as seen in side view, represented, if at all, by but a few setae, sometimes only two or three; in the second and the sixth peraeon segments the anterior row is less complete, while in the latter segment the second row, too, may be feebly developed; in the last peraeon segment both rows may be reduced. In the pleon, the posterior fringes are often restricted to setae along the more dorsal part of the segment, but the short anterior (mid-segmental) row consists of *spines*, sometimes very few in number. On the tailpiece, too, spines are present, mingled with setae, and, here, appear less irregular than in *tasmaniae*, their grouping suggesting two or even three short and incomplete double rows.

Compared with that of *tasmaniae*, the *head* appears less sloping, the forehead rising from the prominence above the eyes; its depth, length, and width are practically equal, there being no appreciable widening behind. The anterior border is rather shallowly emarginate, but is raised, between the eyes, into a short ridge, which is produced variably into a pair of mesial processes, frequently developed strongly as tubercles, which project visibly above the eyes when the animal is viewed from the side; in an immature specimen they may be very much less obvious.

Below the eye is a deep, sub-ocular incisure, from near which a 'genal' groove runs backward as in *tasmaniae*, but it is much shorter in this species, not reaching nearly to the hinder border of the head. From near the inner end of the sub-ocular incisure, a strong groove, bounding the gena in front, runs almost to the ventral surface, marking off a sub-oblong area below the eye, strikingly suggestive of a proximal antennary segment incorporated in the head. From this groove runs backward a ridge which constitutes the ventro-lateral boundary of the head. In almost every specimen this ridge bears an armature of setae (five to seven), these in some cases springing from an upward extension of the ridge towards the sub-ocular incisure. In this it differs from *tasmaniae*, in which, too, the other setae are replaced by spines. The ridge runs above the mandibular articulation (with which in some species it is confluent) and, behind that, in a sinuous course, turning slightly upward, to disappear beneath the antero-ventral extension of the coxa of the gnathopod, reappearing above to define a conspicuous cervical groove. In this posterior part of the head, a considerable area is exposed below the ventro-lateral border, and is variably overlaid ventro-mesially by the lateral border of the epipodite of the maxilliped; it is produced forwardly into a distinct 'posterior' process'. Behind the cervical groove is the maxilliped 'segment' which lacks, in this species, the strong, transverse, spine-bearing ridge so well developed in *tasmaniae*.

The proportions, etc., of the *peraeon* segments are much as in *tasmaniae*, except that they are rather less deep; a bevelling of the terga is seen here as in the surface-living New Zealand forms, to which this species shows many points of resemblance. The first peraeon segment, in dorsal view, shows very markedly

FIG. 51.—*Mesacanthotelson setosus*, sp. n.

the concave margin to both anterior and posterior borders, to which attention has been called in *N. assimilis*. The seventh peraeon segment is less sharply produced antero-ventrally, while fifth, sixth, and seventh are produced postero-ventrally into a seta-armed process. The outer faces of the coxae are comparatively free from spines and setae; the three hindmost are produced into strong processes.

In length, the first three *pleon* segments are sub-equal, the fourth slightly longer, the fifth as long as the combined length of the first three, and, as in *tasmaniae*, equal to the length of the tailpiece not including the telsonic spine.

As compared with the peraeon, the pleon is deeper than that of *tasmaniae*. The pleuron of the first segment is shallow, while those of second, third, and fourth increase progressively in depth. The ventral borders of these pleura are fringed with long, flexible setae, as in *tasmaniae*.

The telsonic spine is distinctly shorter than that of *tasmaniae*, both relatively and actually, slightly upturned, with a distinct dorsal concavity at its base, and, as a comparison of the figures will show, it is differently armed. The related pleuron is slightly more convex and meets the suture defining the sixth pleon segment and the telson closely above the insertion of the uropod. The sutural ridge has three or four setae and may stretch variably from a quarter to half-way across the tailpiece (fig. 51, *3*). The antero-ventral border of the tailpiece (i.e., the free margin of the pleuron of the sixth pleon segment) is armed with from five to seven stout, slightly curved spines, three or four of the shorter (more anterior) of these bearing two or three pectinations terminally, in this agreeing with some *Notamphisopus* spp. (e.g., *dunedinensis*). The hindmost of these spines is particularly stout.

Appendages. The *antennule* (fig. 51, *4*) is shorter than the peduncle of the antenna; the flagellum, which is sub-equal to the three-jointed peduncle, has apparently a maximum of seven joints.[1] On the first peduncle joint there is a fine fur of setules. In a female (with immature brood lamellae) there are, in the flagellum, only four joints, of which the second and third are disproportionately long.

The *antenna* (male) is, relatively, very much shorter and seems more robust than that of *tasmaniae*; in the peduncle, the third joint is as long as the first two, these having a width equal to the length of the third; the fourth is slightly longer than the third, the fifth once and a half times the length of the fourth, but rather less than the third and fourth combined. The flagellum, nearly twice the length of the peduncle, has thirty-two joints. In a female, the flagellum (practically complete) had but fifteen joints.

The mouth parts generally differ little from those of *tasmaniae*. The *labrum* (fig. 52, *5*) is deeper and differs somewhat in shape; the right mandible (fig. 51, *6r*) has a spine-row less well developed and there are differences in the armature of the palp—the setae arming the third joint are disposed, in *setosus*, in three or four sub-terminal transverse rows, some being coarsely denticulate, others finely pectinate, but in either case on one side of the setae only. Further, although there are numerous setae at the end of the second joint, only a few are pectinate.

Labium (fig. 52, *7*). The mesio-ventral angles of the outer lobes appear more angular and the mesial and lateral fringes of setae are practically continuous. It is on an example of this species that the occurrence of setospines in the mesial marginal brush is most evident, their presence indicated by the retraction of the protoplasm of the actual setospines.

[1] Seven on one side and six on the other, in one specimen.

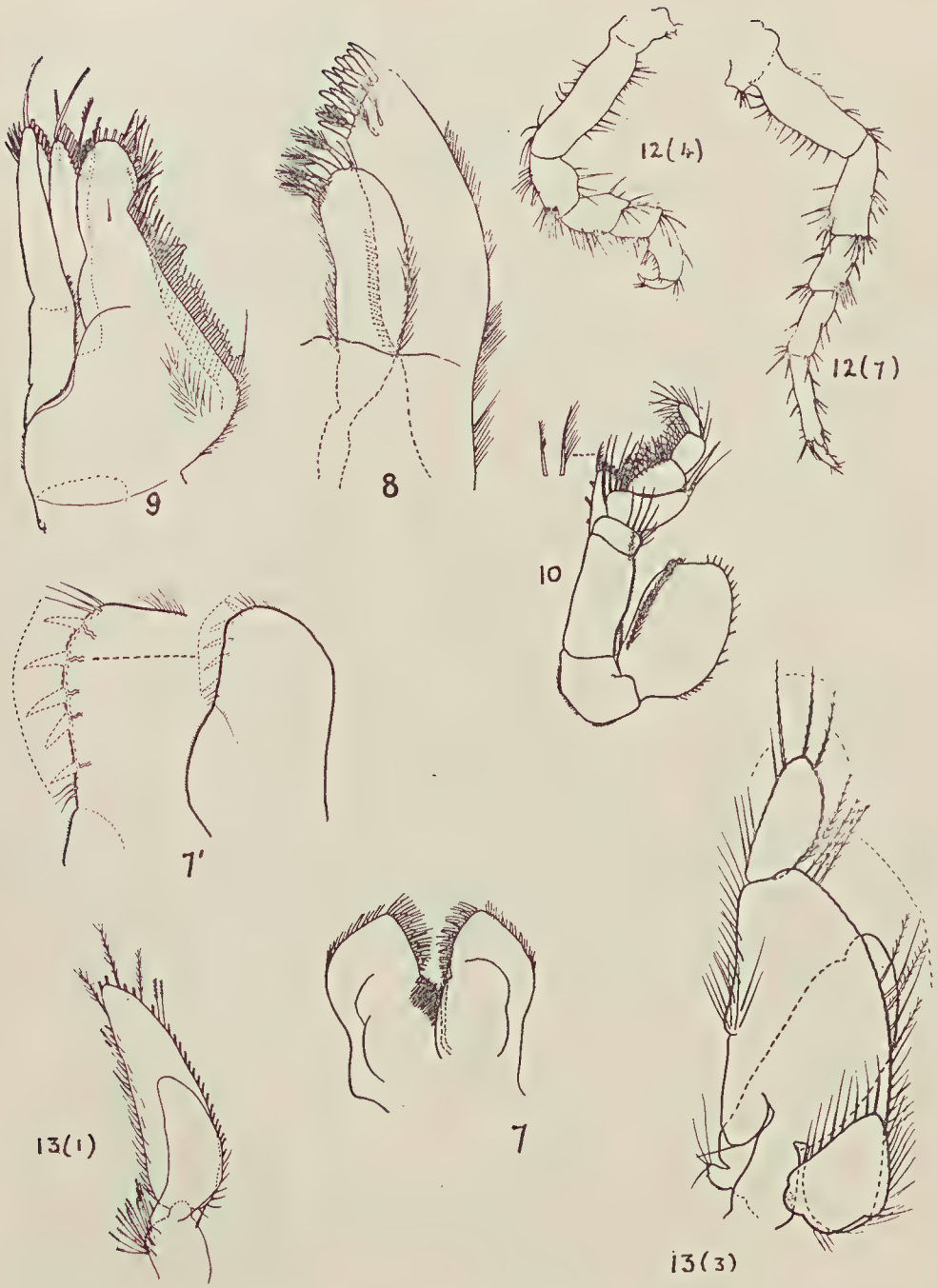


FIG. 52.—*Mesacanthotelson setosus* (7'—lobe of labium more highly magnified).

In the *maxillula* (fig. 52, *8*), the principal differences are seen in the distal endite which is less noticeably narrowed apically (and its spines, therefore, less crowded); the sub-terminal plumose setae on the posterior face are reduced to two, and never more than one setospine is found in the apical series of spines.

Maxilla (fig. 52, *9*). In this appendage, the outer endite appears narrower and the characteristic tuft of setae on the outer border, near its base, is wanting. On the proximal endite, the filter setae are arranged in the usual single row; on the anterior face of this endite there is a short basal tuft of simple setae instead of the long rank running the whole length of the endite.

On the posterior face there is the normal single rank of pectinate setae, and this begins more proximally and springs from a ridge which is farther from the mesial edge; the setae are less numerous, about thirty in all. In the *maxilliped* (fig. 52, *10*) there are fewer coupling hooks (three instead of four) set far more distally, the appendage as a whole being less setose; on the endite there were found only about fourteen brush setae, all of which seem to carry cilia on the distal face only. At the outer distal end of the basis are two spines, apparently not plumed. The epipodite has the whole of its outer margin crenate and set with spinules.

The *gnathopod*, in the male (fig. 51, *11* ♂), differs from that of *tasmaniae* in the proportions and the shape of the hand. The propod has a width barely three-fourths of its greatest length; moderately convex anteriorly, it is quite definitely concave on its posterior border, which is barely half the length of the palm; the palm is sinuous, convex for three-fourths of its length, concave near the base of the dactyl; its armature of about fourteen denticulate spines is like that of *tasmaniae*, but the spines are less stout and are followed distally by four or five simple spines; the slotting on the palmar border of the dactyl is undeveloped. In the female (fig. 51, *11* ♀) the propod is more narrowly sub-triangular (as in *tasmaniae*); the slotting of the dactyl is strongly marked, and there are twelve to fourteen spines on the palm of the propod.

The peraeopods (fig. 52, *12(4), (7)*) are to be distinguished from those of *tasmaniae* principally in that they are armed mainly with longish flexible setae, this difference being particularly noticeable in the more proximal joints of the fourth to seventh peraeopods, whereas in *tasmaniae* there are close-set ranks of short, stout spines. In the fourth peraeopod of the male, the ischium is shorter, being barely half the length of the basis, and the dactyl is without the apical (palmar) tuft of setae. In the hinder group of legs, the more distal joints of the peraeopods of *setosus* are, perhaps, relatively less elongate and more robust than in *tasmaniae*, but in both species spines are here present; in addition there are several small sensory (plumose) setae on the bases.

The penes are alike in the two species, excepting that those of *tasmaniae* are armed with spinules, those of *setosus* unarmed.

Females are not abundant and there are none mature in the collection examined. One (16 mm. in length) shows the brood lamellae as small leathery flaps; a well-defined triangular area just internal to the coxa of the fifth peraeopods apparently include the future oviducal opening; springing from the coxa of its seventh peraeopod, on the left side only, is a slender penis

The *pleopods* show minor differences in the setation of the exopodite and in the processes bearing the entangling setae. There are also differences in the shape of the attachment of the epipodites. On the sternite in the mid-line between the first pair is a rounded boss in the male, a low hump in the female.

First pleopod (fig. 52, *13(1)*). The exopodite is narrow, lanceolate, with about nine or ten plumose setae borne on the distal margin. Along the nearly straight inner border are long slender setae, mostly finely pectinate, in the distal half some arising sub-marginally on the lateral border, the rank of plumose setae is extended interruptedly rather more proximally than on the inner border; pectinate setae extending almost to the proximal end; some setae, mostly simple, are borne sub-marginally. The endopodite, which arises on a narrow, curved stalk, is scarcely two-thirds of the length of the outer lamella, is narrower, more rounded apically, and quite devoid of setae. The entangling setae are numerous and pectinate, and arise in two or three tufts.

The second pleopod in the male is longer than the first, by the extent of the second exopodite joint; the mesial border of the basal joint of the exopodite has a thick fringe of short, pectinate setae, only two or three terminal setae being plumose; on the second joint, also, the greater part of the mesial border has pectinate setae, but near the apex, plumose setae appear, and these continue along the outer border for its distal half; there are a few interspersed simple setae, and these constitute the fringe along the proximal half of the outer border. The endopodite is as long as the proximal joint of the exopodite and is recognizably divided into a common basal region and two distal portions, an outer respiratory lamella and a longer mesial scroll-like stylet, curved, its hollow directed mesially, the free edges armed with a fringe of short setae. Apically the stylet is armed with three or four stiff spine-setae. The sympodite is irregularly four-sided, its mesial border shorter than the lateral, and its distal half occupied by a short entangling lobe carrying a dozen or so long pectinate setae; it lateral border appears unarmed.

Succeeding pleopods differ in several details; the endopodite in the third is slightly longer than that of the second; only the distal half of the mesial border is setose; upon the rest of the joint plumose setae are present much as in the second, but the simple setae proximo-laterally are fewer. On the sympodite the entangling lobe becomes increasingly conspicuous.

Uropod. As in *tasmaniae*, this is very elongate, but differs in its armature, the peduncle bearing two spines on its ventral border; scattered spines on the inner dorsal edge are few, but rather more plentiful on the outer edge; the rami are stout; the inner may be a little longer or not quite as long as the peduncle; the outer ramus is armed with two spines, one at its mid-length, the other more proximally; usually three spines arm the inner ramus. The spine beneath the insertion of the rami is stout and multi-toothed. In the female, the uropods seem relatively shorter.

Size. Largest male about 19 mm.; largest female (immature) 16 mm.

Colour. Uniformly dull grey (in spirit).

Occurrence. Dredged along the old shore line at the north end of the Great Lake (D. Spargo, 22.12.33). Also from the collection made by J. W. Evans, obtained from the stomach of trout.

Mesacanthotelson tasmaniae (G. M. Thomson)

(Figs 53 and 54)

Thomson, G. M., 1894, p. 349, pl. 11 (part) *(Phreatoicus tasmaniae).*
Sheppard, 1927, p. 94, figs 2(2)-(5), 3, and 4 *(Phreatoicus tasmaniae).*
Smith, Geoffrey, 1909, p. 73, pl. 12, figs 7, 8, and 11 *(Phreatoicus spinosus).*

The body is sub-cylindrical, being flattened ventrally, maintaining in the male, between the third and seventh peraeon segments, an almost uniform width, which

is rather greater than the depth in this region. The head and first peraeon segments are, however, distinctly narrower than the peraeon, while, posteriorly, the pleon segments and tailpiece taper, at first gently and then sharply, to pass abruptly into the long spinous telsonic process, so that viewed from above, the animal appears of an elongate fusiform shape. Actually the length of the body is about six and one-half times the greatest width.

The surface is produced into stout spines, distributed somewhat irregularly upon head and tailpiece, but more regularly on the body. On the first peraeon segment, they are arranged in a single, short, wide band, which consists of a double rank of spines, while on the second to the seventh, there are two more extensive bands in each segment, the second, which is separated from the first by a deep groove, lying close to the hind border. In the first four pleon segments there is a single row of these spines situated posteriorly and forming a backwardly-directed fringe, but in the second to the fifth, there may frequently be found a feeble development of a mid-segmental row on a slightly elevated ridge.

The *head*, long, shallow in front, slopes upward irregularly to its hinder border. Its length equals its greatest depth, but is rather less than its width; the anterior border is very shallowly emarginate. The eyes, long-oval in shape, are prominent, placed laterally and obliquely, each having about sixty facets; the width of the interocular region is between once-and-a-half and twice the longest diameter of the eyes; is slightly concave and practically free from tubercles; in front it is raised into a well-marked ridge which becomes slightly sinuous just in front of the eyes, and may be produced into a pair of small elevations, or may bear one or two pairs of slender spines. Below the eye there is a short, wide sub-ocular incisure from which a shallow groove curves towards the hinder border of the head, forming the upper boundary of a wide gena or cheek and fading out behind at the level of the suture of the coxa of the gnathopod with its segment. The sub-ocular area is fairly well defined; a spine-bearing ridge marks off the ventro-lateral border of the head, the anterior half of which appears as a smooth band of variable width, part of its lower edge providing the mandibular articulation, this latter being at first practically horizontal, and then strongly inclined ventrally (fig. 53, *2s*). Below the mandible there is a very small 'posterior process' clothed with fine setae, which are present also on the adjoining surface of the mandible. Behind, this ventro-lateral border widens into the post-mandibular region (the lower part of the maxilliped segment) and is normally overlapped below by the epipodite of the maxilliped (displaced in the figure), while its upper limit is indicated by the spine-bearing ridge which, turning dorsally, seems to define the lower end of the cervical groove. At this point it is hidden by the coxa of the gnathopod, but, above, the cervical groove is particularly well-defined; dorsally (fig. 53, *2d*) it is incomplete. The maxilliped segment bears a slight transverse elevation with two or three spines (obviously comparable with the row on the first peraeon segment) and its posterior margin forms the depressed articular area of the head.

The *peraeon* segments all have a depth greater than their length. The first is but half the length of the head, with which it appears fused[1], below it widens distinctly. The second and fourth segments each almost equals the head in length; the third is slightly the longest; the fifth and sixth are shorter, while the seventh is barely two-thirds of the length of the third. The antero-ventral angle of the first peraeon segment is sub-quadrate, armed with a couple of short spines, a variable cluster of spines springing from both lobes of the large coxa of the

[1] There seems a slight mobility here in some specimens.

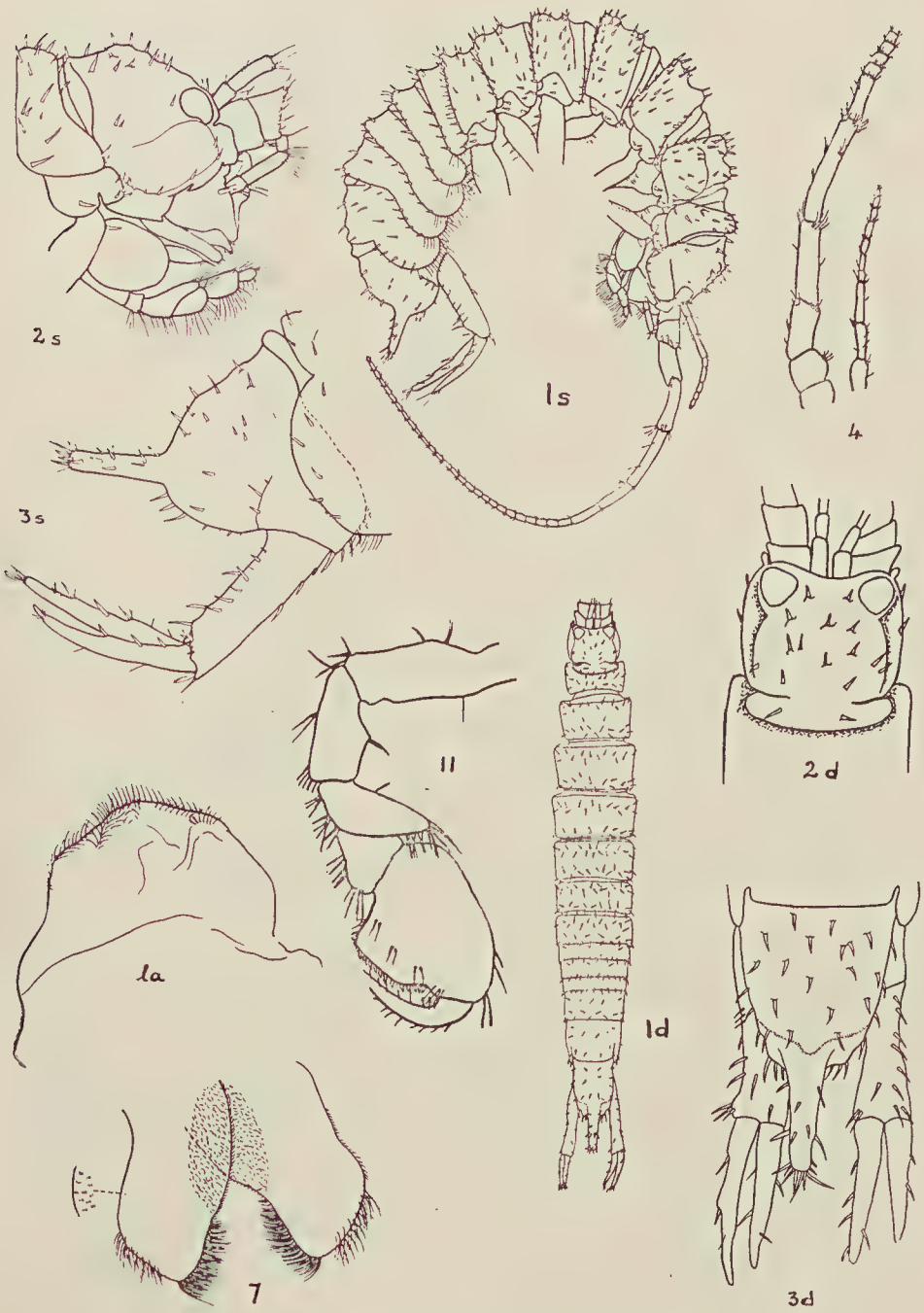


FIG. 53.—*Mesacanthotelson tasmaniae* (G. M. Thomson).

gnathopod. The next three segments have the antero-ventral angle downwardly produced in front of the respective coxae into an angular process, armed with a small group of spines. The fifth to seventh peraeon segments, also, are produced antero-ventrally, but the corners are more rounded and spines occur along the ventral borders. The postero-ventral angle in the first three segments is rounded; in the fourth it appears more angular, while in the posterior three segments, the ventral border is deeply excavated and the hinder margin shortened to accommodate the coxa of the related limb; the actual coxae are produced backwardly in a strong process which is armed with one or more spines. All the coxae are large (only the fourth somewhat reduced), and may bear sparsely-scattered spines.

The *pleon* segments increase progressively in length from the first to the fifth, the first being about half as long as the seventh peraeon (or the fourth pleon) segment; the fifth has a length sub-equal to the combined length of the first three, and is as long as the tailpiece, not including the telsonic projection; there is, also, in each a progressive increase in depth from the first to the fourth pleon segment. The ventral border of the second to fifth pleura is fringed with curved, slender, flexible setae, the first pleuron having a less complete fringe.[1]

The tailpiece is unique among extant forms, in the extreme elongation of the telsonic spine (cf. *Acanthotelson*). This is armed, a little variably, with some setae and one or two pairs of stout spines terminally, and with paired spines at one or two nodes along its length. The telsonic pleura are slightly convex below the base of the projection and armed marginally, each with a few (six to eight) moderately strong spines of variable length. The incomplete suture between telson and sixth pleon segment is to be seen extending antero-dorsally from the insertion of the uropods, and bears two, rarely three, spines. Between this and the uropod the border is fringed with setules.

Anterior to the insertion of the uropod, the pleuron of the sixth pleon segment is relatively deep and narrow, its ventral border having five close-set, strong, curved spines, some being toothed apically, while immediately beneath the uropod insertion there is a much stouter, simple spine flanked by two smaller spines (cf. *Eophreatoicus*).

In the specimen figured, the pleon has scarcely two-thirds the length of combined head and peraeon, the latter region being shown fully extended. In the figures given by Geoffrey Smith and Miss Sheppard, the pleon appears longer relatively.

Appendages. Some of these have been figured by Thomson and by Sheppard. There is, apparently, considerable variability for, in several instances, my preparations show marked divergence from the condition recorded by the latter author.

Antennule (fig. 53, *4*). The peduncle is sub-equal to the flagellum; the first joint is expanded and covered with scale-setae; the second and third are slender; the third is longest. There may be as many as nine joints in the flagellum,[2] the last four or five of which (fifth to end) bear two or three characteristic sensory setae apiece, the 'olfactory cylinders' of Chilton's descriptions; the end joint has unusually but a single olfactory cylinder.

---

[1] The development here, of flexible setae, is probably related to the habit of rolling up. Stiffer spines might make this operation more difficult.

[2] The number will naturally vary in growing specimens, but even in mature specimens there can be considerable variation in the number of joints of the flagellum of the antennule. Thus, males are found with seven and nine joints, or seven and eight, in flagella of opposite sides; or with seven on both sides; three females examined showed seven on both sides, a fourth (with immature brood lamella) had six joints on both, while a fifth had seven flagellar joints in one, with eight on the opposite appendage.

The *antenna* is stout and attains to a greater length than in any other Phreatoicid. The peduncle is very strong (fig. 53, *4*), but owing to the proportions of the several joints which diminish relatively slightly in thickness, this robustness is not so obvious in the figures of the isolated appendage. In one detail it differs markedly from Sheppard's account, for the fourth joint of the peduncle is half as long again as the third joint instead of shorter as stated by Sheppard (l.c., p. 96), while the fifth is only about one-third longer than the fourth, thus agreeing with the condition figured by Thomson. In the male, the flagellum may have at least as many as thirty-nine joints and the entire appendage is, in some examples, practically as long as the body of the animal, the flagellum thrice the length of the peduncle; an unusual, but not invariable, feature is the length of the first two joints of the flagellum. In the female, twenty-six joints seem to be normally present, but in one female, with developing brood lamellae, forty-five joints were counted.

In immature specimens, the appendage is shorter; thus Thomson (1894, p. 350, pl. II, figs 1, 2) described the flagellum as 'somewhat exceeding the peduncle in length' and figures the antenna as about 4 mm. in length, noting that his largest male had a length of 'a little over half an inch'. Sheppard, with specimens from '15 mm. to 23 mm.' in length, finds the antenna 'rather more than half the length of the body'.

In view of the facts that the three closely-related species, *tasmaniae, decipiens,* and *setosus* show a marked difference in the length of their antennae, and that Smith's figure of '*spinosus*' and his description record the antennae as very long, also, that Sheppard's figure differs from those of Thomson, it may be (i) that the material collected by Geoffrey Smith contained examples of at least the first two of these species, and (ii) that the specimens from G. Smith's collection examined by Sheppard were not specifically identical with those selected and figured by Smith as the types of his species *spinosus.* Sheppard's identification of *spinosus* with *tasmaniae* is thus open to question, and it is possible (i) that *tasmaniae* G.M.T. is actually distinct from *spinosus* and (ii) that it is the species *decipiens,* described below, which is identical with *tasmaniae* G.M.T.; (iii) that *tasmaniae* of the present account should be assigned to *spinosus* Geoffrey Smith.

Alternatively, if Sheppard's identification of *spinosus* G. Smith with *tasmaniae* is really correct, the discrepancies in descriptions and figures must be attributed to the recording of conditions in immature specimens, or perhaps to variation in the specimens examined.

Labrum (fig. 53, *la*). The upper lip is very stout and prominent, although in outline it appears long and narrow. It is movably attached, along a markedly asymmetrical hinge-line, to a well-developed epistome. Upon the external face there is a median ridge, which projects in a well-developed prominence, on either side of which the surface is concave, a condition suggestive of a reduced or under-developed, sub-rostral spine.

Mandibles. The left differs from the right (fig. 54, *6r*), as is usual in this family, in the condition of the molar, as well as in the possession of a *lacinia mobilis.* The joints of the palp retain the relative proportions commonly found in the Phreatoicidae. The palp as a whole is quite long and its armature of spines and setae is exceptionally well developed. Near its attachment there is one stout spine; the distal end of the first joint bears a group of three stoutish spines and some setae; not only does the distal end of the second joint carry the usual terminal, rather comb-like, series, consisting here of nine long, slender, pectinate setae, but there is also a rank (varying in number in the two palps) of slender setae along the distal fourth of its upper border, and a fringe of setules on the opposite border; the third joint is of the usual sub-crescentic shape but the

concave setae-bearing part of the edge is very long (nearly two-thirds of the length of the joint), with numerous setae carried in a triple rank, some simple and others finely pectinate, a few coarsely denticulate. They are more abundant on the left appendage; in both, the apical setae are doubly pectinate. As compared with *setosus*, the setae in this region are more plentiful in *tasmaniae*. In one specimen, there was retained a condition which has been observed in no other Phreatoicid—one exceptionally long seta, normally appearing terminal in this series, arising in a well-marked notch on the convex border of the joint. Fine setae partly cover the inner surface of the joint.

Just dorsal to the insertion of the palp, the fulcral process projects as a rounded knob which fits into a corresponding hollow near the antero-lateral corner of the head.

The spine row is a highly flexible structure, but, unlike the lacinia mobilis, does not appear to be articulated with the primary dentate piece. In both mandibles, the spine row consists of a narrow flange, its free edge slightly flattened into a plate almost at right angles to its axis. From the borders of this plate, the paired spines diverge slightly and are denticulate on their mesial surface. In both mandibles, the spine row is followed by two or three (occasionally four or five) slender plumose spines which have presumably escaped incorporation in the row.

Labium (fig. 53, *7*). There is practically no differentiation into outer and inner lobes. The ventral ends of the lobes are sub-rectangular, the corners gently rounded; mesially it passes into a flexible median fold, the paired surfaces of which are densely setose and form an inverted trough leading to the mouth. The mesial surface of the outer lobe is densely furred with long setae; the outer distal surface is more sparsely setose, the two setal tracts being separated by a short gap; the outer distal fringe passes gradually into a sub-marginal fur of short setae, which decrease continually in length proximally, until they are replaced by short scales whose free edges are dissected into a short, curved line of setules. Such a scale-like condition probably forms the covering over nearly the whole of the outer surface of the body, but can probably be seen nowhere more readily than on the outer edges of the proximal part of the labium or on the corresponding region of the maxillula and maxilla.

Maxillula (fig. 54, *8*). Miss Sheppard has devoted considerable attention to the structure of this and the succeeding appendage of this species (1927, pp. 85 and 96/97), and while she has, it seems, entirely missed certain essential features of the maxilla, there is little to be added to her account of the maxillula. It must be noted, however, that here, as elsewhere in this species, there is a rather unexpected variability.

Thus, on the *inner endite*, the number of apical setospines, normally four, may sometimes be increased to five, in which case the two stout spine-setae lie against the first and third (counting from the outer edge); normally, these two spine-setae lie well external to the first and between the second and third. Again, the inner half of the apex of this endite may be thickly furred with slender setae shorter than, but otherwise resembling, the setae which cover the mesial border of the endite.

On the *outer endite*, the terminal short, stout spines are arranged in two rather uneven rows; the number seems to be inconstant (eleven to fourteen) but of them, one (in several specimens, two) near the inner edge of the posterior row is a setospine very like, but smaller than, those normally present on the inner endite. The stouter (outermost) spines may be simple, but most of the series are coarsely denticulate.

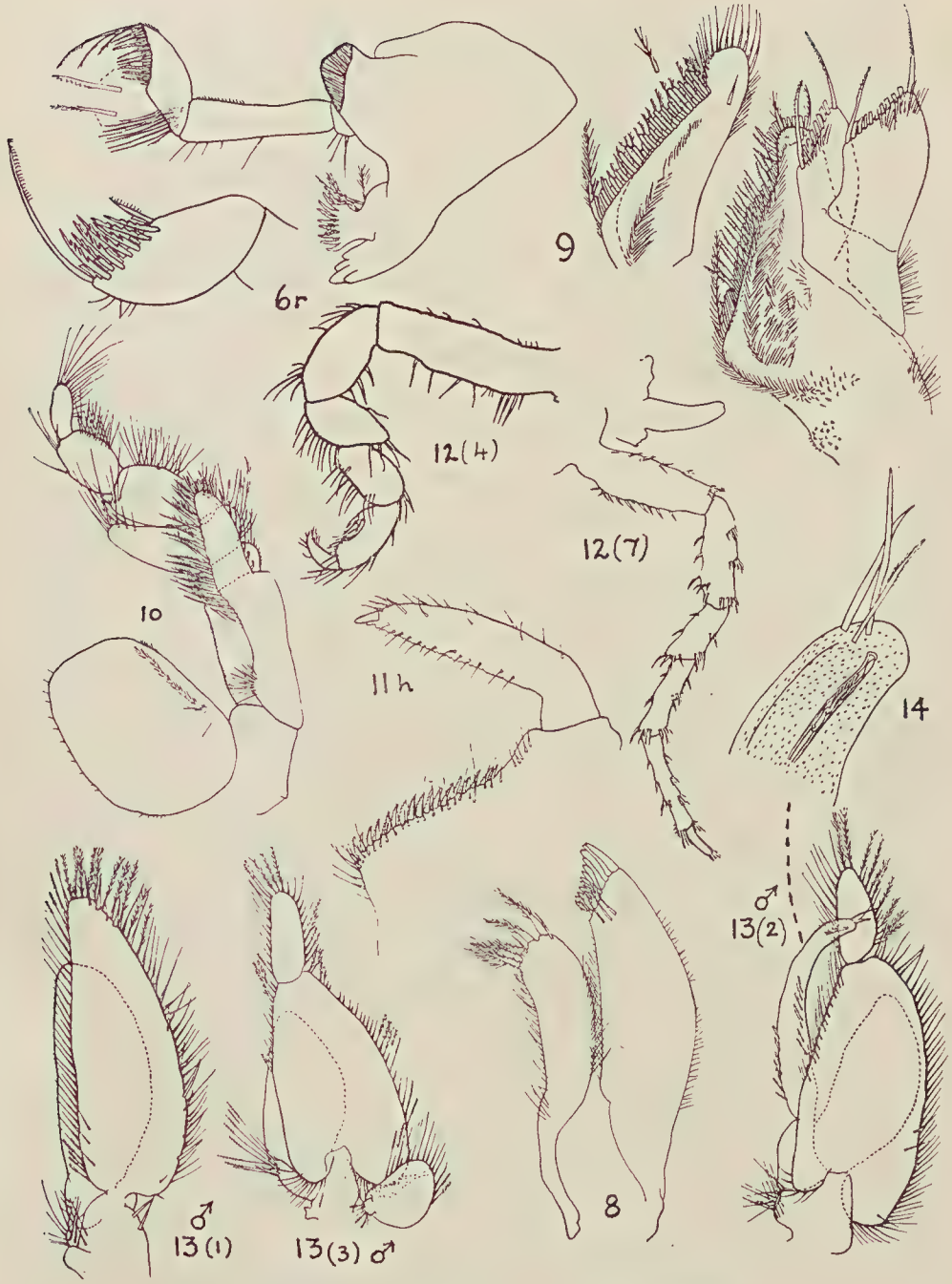


FIG. 54.—*Mesacanthotelson tasmaniae* (G. M. Thomson).

On the *posterior* face of the endite, near it distal end, is a broken rank of slender, plumose setae. Sheppard records only two setae here, but in large specimens there are usually three, scantily ciliated and occasionally one (the innermost) may be almost simple. In one example (the largest male examined), four[1] of these setae were found on both right and left appendage; the additional seta (more mesial in position) being more strongly ciliated than the others.[2]

Maxilla (fig. 54, *9*). The structure, and particularly the armature, of this appendage is much more complicated than would appear from existing accounts and, up to a point, displays a striking likeness to the condition in *Apseudes* and *Mysis*! The three endites are set somewhat obliquely; the innermost (fixed) lobe or proximal endite is wholly anterior, the inner free lobe (inner distal endite) lying partly concealed behind it and, in its turn, it partly covers the outer distal endite.

The proximal endite has its inner border broadened to constitute a mesial surface; from the anterior border of this mesial surface springs a rank of about fifty slender filter setae forming a close palisade, the apices of the setae being plumed with two ranks of fine cilia.

Towards the distal end, this row of setae is found to pass laterally a little onto the anterior face of the lobe where it stops abruptly, short of the apex; lateral to it lies one stout spine. Laterally to the row of filter setae along the anterior surface is a ridge armed with short setae. Much of the posterior surface is clothed with a dense fur of shortish setae; at the proximal end of the innermost ranks there is a thick band of simple setae which passes laterally on the hinder face.

Upon the posterior edge of the mesial surface, sub-marginally, lies a confused series of much more loosely-grouped setae, as many as thirty-five in some specimens. Proximally, they appear simple, but as they are traced distally they become stouter and show a pectinate condition, or, variably, are feebly plumose; finally this series is merged in the terminal cluster of stout setae, predominantly plumose but including some slender, simple setae and others spinous and with stout denticulations. The latter are more in evidence when the posterior surface of the apex of the endite is examined; the occurrence of plumose setae here is of interest, since such setae are, also, found in *M. capensis* and in some New Zealand species.

The inner of the two distal endites projects apically very little, if at all, beyond the free end of the proximal endite; the outermost is wider and extends slightly more distally. The apices of both are obliquely truncated and bear a row of long, curved, pectinate, or even serrate, setae. The denticulations vary from coarse to fine, the finest being practically pectinations; just sub-terminal are short rows of simple setae.

On the lateral border of the appendage, on the outer aspect of the second and third segment (Sheppard, text-fig. 3 (2)) are two clusters of slender setae directed distally; the more proximal is sometimes whorled.

The *maxilliped* (fig. 54, *10*) has been described in detail by Sheppard. In many particulars, however, there was found a departure from the condition recorded, and it would seem that in this appendage, also, there is considerable inconstancy in setation and perhaps even in proportions.

---

(1) Cf. *Synamphisopus* and *Colubotelson setiferus*, where there may be five.

(2) In her figure of this appendage (fig. 3, (4)), Sheppard indicates the presence of similar plumose setae sub-terminally on the inner endite, also. No reference is made in the text to this detail, however, nor could there be found any trace of such setae. It can only be supposed that the structures figured are protoplasmic retractions from the setospines.

It should be noted that, even when allowance is made for the relatively large size attained by this species, the maxillipeds are unusually large and stout, and the palp long, extending in front of the anterior surface of the labrum. Perhaps the most unusual feature is the large development of the coxa which may have a length more than three-fourths of that of the basis (not including the endite), while the width and length of the basis measured in a 12 mm. specimen is approximately three-fourths of similar measurements of the basis of the gnathopod.(1)

The outer distal angle of the basis bears two stout, plumose spines. The endite of the basis is long—on its ventral edge is a series of four coupling hooks, which is continued to the apex of the endite by a short row of thick, curved and barbed spinules, these giving place to the terminal pectinate setae. The dorsal edge of the endite bears a long fringe of about twenty brush setae; proximally, and separated from these by a short gap, is a cluster of long stiff setae. The epipodite is large, its outer border armed with spaced setules, with an occasional spine; the inner surface bearing the usual sub-marginal series of setae, which are longest near its base. In an immature female the ventro-mesial corner of the coxa is scarcely produced but bears a serried rank of short setae.

Gnathopod. In the male, the basis, which bears a few spines, appears relatively rather shorter and wider than figured by Sheppard; the ischium bears one or two stout spines anteriorly; the merus is strongly produced, the apex of the process armed with a very stout spine with flanking setae on either side; the propod, at its greatest width, is three-quarters as wide as long, its anterior border convex with a couple of tufts of setae distally. The posterior border, which is half the length of the palm, is almost straight but slightly concave proximally; the palm, straight for more than half its length, becomes concave near the attachment of the dactyl; it is armed with fifteen to sixteen stout spines, strongly denticulate on their posterior edge, the dactyl scarcely reaching the end of the palm, the inner border serrated, the outer with sparse setae. In the female, the limb is shorter and more slender, the propod sub-triangular with steeply oblique palm, notably setose. The denticulate spines are fewer and more slender; the inner border of the dactyl slotted apically so as to cut it into a series of incisor-like teeth, but these tend to become short, sub-conical spinules nearer the base of the dactyl. In the three succeeding peraeopods, the ischia and merus are very slightly expanded, the dactyls of second and third have a small secondary unguis; the propod of the fourth is elongated but appears rather less angular than represented in Sheppard's figure. In a large immature female, 18 mm. in length, the sternite of the fifth peraeon segment showed a pair of small flexible flaps—obviously vestiges of a fifth pair of oostegites. Usually the sternite of this segment has two well-marked triangular regions, the nearly mesial apices apparently marking the oviducal aperture.

The fifth, sixth, and seventh *peracopods* show progressive increase in length; on the basis of the sixth and seventh there is found a trace only of a flattened flange along part of the hinder border. Upon this hinder margin may be found one or more small ciliated (sensory) setae.(2) Ischium and merus, too, are slightly flattened, but all are relatively very much less expanded than figured by

(1) The maxilliped of this small (12 mm.) *tasmaniae* is rather longer than that of a fully-grown *orarii* (15 mm.) and as long as that of a large *pearsoni* (18 mm.); in the fully-grown *tasmaniae* (23·5 mm.) its size is almost doubled.

(2) A small cluster of such setae occurs distally on the propod just above the insertion of the dactyl.

Chilton for *australis*; the dactyl is elongate. These limbs are notable for their armature which consists of numerous stout, but short, spines, the spininess reaching a greater development than in any other Phreatoicid species, and is scarcely rivalled even by *Eophreatoicus* or *Synamphisopus* among the Amphisopidae. In the male, the penes are strongly curved, and so long that their apices meet in the middle line. There seem to be spines related to this structure, but these may be actually borne on the sternite, for there is a transverse row of spines on each peraeon sternite, a feature peculiar to this species. In one female, a single penis was present, on the left side.

Pleopods. The pleopods in this species have received scant notice. Geoffrey Smith omits all mention of them, while Sheppard dismisses them in three lines, as being of the usual *Phreatoicus* type and bearing a close resemblance to those of *M. australis.* In actual fact, in the first pleopod, at least, there is a marked difference from that of all other Phreatoicids, in that on both exopodite and sympodite, it bears stout sub-marginal *spines.* In this first pleopod (fig. 54, *13(1)*), the sympodite, seen in anterior view, has the usual sub-quadrangular shape; on its inner aspect, it is produced into a large lobe which bears mesially a tuft of long entangling setae, while upon its outer distal angle is a powerful spine (sometimes two) in the male, these being less developed in the female.

The endopodite is scarcely oval as figured (1927, fig. 4 (8), (9), (10)), but has a practically straight inner border and is nearly four-fifths of the length of the exopodite. The exopodite bears the usual fringe of plumose and simple setae; a number of long, simple setae provides a complete fringe along the mesial border and proximally there are a few sub-marginal setae, also. Upon the outer aspect, at several points, the setal fringe is irregularly interrupted by the presence of stout spines, and there are a few (mostly apical) simple setae sub-marginally (cf. *flavius*).

The second pleopod, in the female, differs from the first (apart, of course, from the subdivision of exopodite into proximal and distal lobes) chiefly in the absence of spines from the exopodite and the larger development of the mesial plate upon the sympodite which bears the entangling setae. These setae are very numerous, long and stiffly pectinate or serrate.

In the male, however, there are certain details in which the appendage is marked off from that of other Phreatoicids. The endopodite is relatively shorter than that of the first pleopod, the basal lobe unusually strong, the penial stylet strong and tending to taper slightly towards its apex, which is curved. There is well developed an armature of slender spines along *both* free edges of the stylet, and there is an apical and sub-apical cluster of stouter spines, some of which may be serrated. One of these—which is sub-apical and springs from the inner surface of the scroll-like stylet and appears to be introverted, but is apparently capable of eversion—is only variably present. In the specimen figured it is seen to arise a little short of the apex and to lie rather crumpled in a tubular cavity. A second specimen shows it half everted. It is distinctly stouter than the other spines in this region and strongly serrated. The apical cluster differs, also, from that of *Mesamphisopus, Eophreatoicus, Uramphisopus,* and *Onchotelson* in that the number of terminal spines is quite small, probably not exceeding three.

Between the pleopods of both the first and second pair of the male is a distinct median sternal boss. It doubtless represents in a much reduced condition the structure figured as occurring on the second pleon segment of *Eophreatoicus*

kershawi.[1] In the immature female it is more rounded and, in the preparation, strongly wrinkled; indeed, the folding suggests the presence of an irregular slit-like orifice, but no mature female is available for study, and it may well be that the apparent opening is an artifact.

In the succeeding pleopods, there is to be noted a progressive decrease in the size of the endopodite, an increase in the development of the coupling lobe which may bear not only the usual group of long entangling setae but also, more proximally, a fur of short setules.

In the exopodites, the plumose setae on the outer border may extend farther proximally than in the first and second pleopods, but the mesial setal fringe is restricted to the distal half of the proximal plate. On the distal lobe, most of the mesial setae are pectinate.

The epipodites, which are sub-oval in shape, may bear a small basal lobe just proximal to the insertion of the narrow stalk, but this, like so many features in *tasmaniae*, is of variable occurrence.

Uropods (fig. 53, *la*). These are slender and longer, both absolutely and relatively, than in any other species, projecting well beyond the elongate telsonic spine. The peduncle is long, broadens posteriorly on its dorsal (concave) surface, the two diverging edges being armed with regularly spaced spines. The inner ramus, which is very long and may actually exceed the peduncle in length, bears two or three stout spines and is sharply pointed terminally. The outer ramus is distinctly shorter, and bears no fewer than three spines on its proximal half. Beneath the insertion of the rami is one, stout, and a second, smaller, toothed spine, flanked by several slender simple spines.

Colour. The body generally is greyish, sometimes quite dark but, in life, is relieved on antennae and legs by bars of orange or reddish chestnut.

Size. Up to 23·5 mm.

Occurrence. Great Lake, Tasmania.

Mesacanthotelson decipiens, sp. n.

(Figs 55 and 56)

A small form, very near to *M. tasmaniae*, but perhaps with affinities to *Colubotelson tattersalli*; from both of these, however, it may be at once distinguished by the condition and armature of the terminal telsonic projection. It has, also, much in common with *O. brevicaudatus*, from which it is readily separated by the condition of the head and the lesser degree of ridging and setosity, as well as by that of the telson.

Body sculptured and with slight ridges, sparsely setose, the setae long and flexible. The *head* is as long as the combined length of the first and second peraeon segments; its maximum depth is greater than either its length or width. In front it is moderately excavate, its anterior border raised, and there are some

(1) Reference was made in Part I of this paper (1943, p. 108) to this structure which, by some slip, for which the writer is utterly unable to account, was compared with a '*petasma*'. Obviously it had no sort of likeness at all to any petasma, but a much more evident resemblance to a Penaeid '*thelycum*'. The point which was to have been made was that in the *male* of *Eophreatoicus* there was perhaps a structure of the character of a *receptaculum seminis*, on a segment normally modified, if at all, only in relation to the male; if so, it would furnish yet another instance of the existence of male and female characters in a member, and a particularly primitive one, of this sub-order. It must be remembered that the adult female of this species has not been observed and that this structure may prove to be a normally functional female organ at the ovigerous stage.

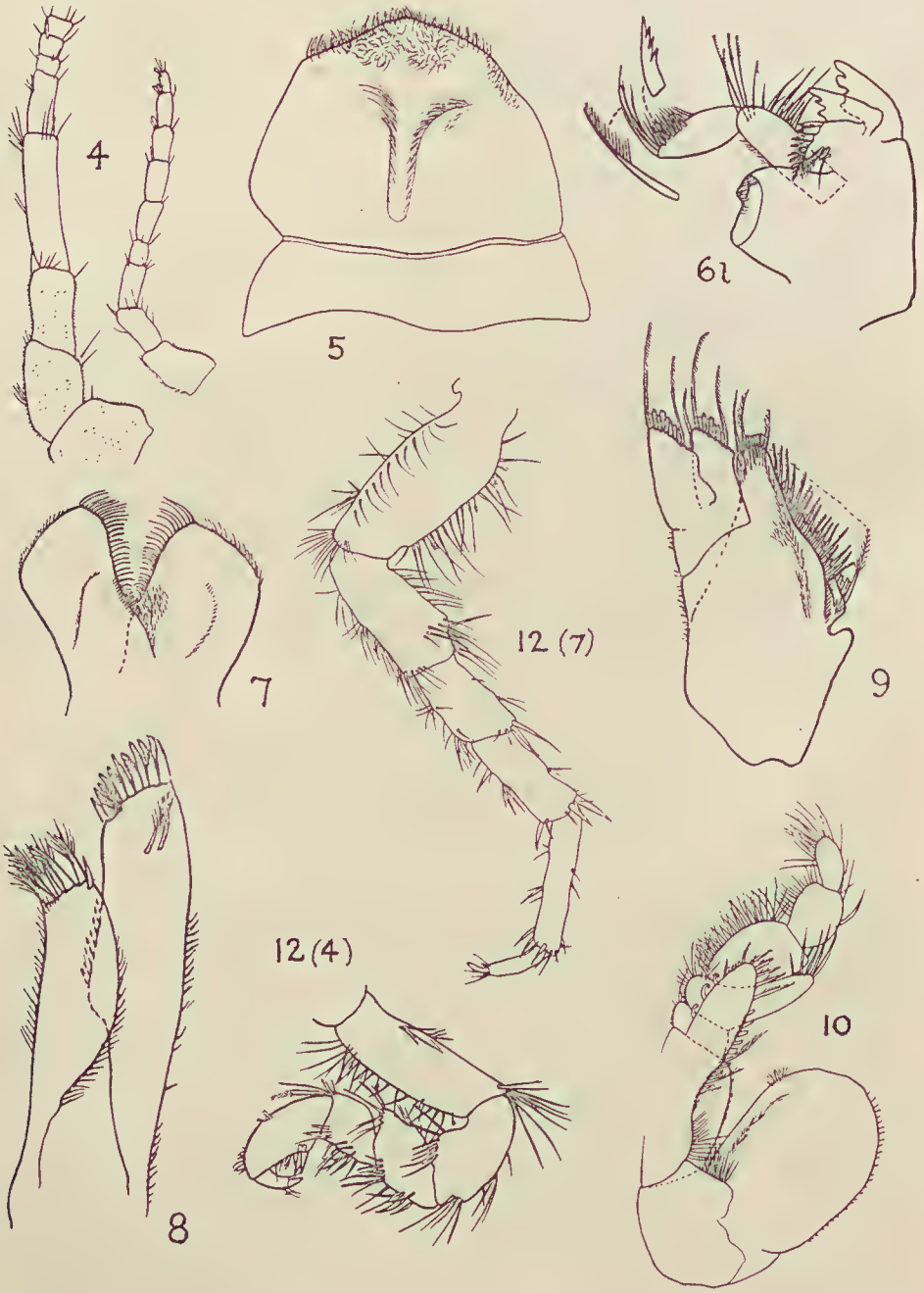


FIG. 55.—*Mesacanthotelson decipiens*, sp. n.

irregular elevations in the slightly concave inter-orbital area, which has a width about twice that of the greatest diameter of the eye. The oval eyes, with approximately 40 facets, are only moderately prominent, and the hollow behind the eye is accordingly much less marked than in *brevicaudatus*. Unlike that species, too, the genal groove is long, almost completely separating the cheek from the more dorsal part of the head. The sub-ocular incisure is a wide and shallow notch above the pre-antennary area which is well defined. The ventro-lateral border of the head appears as an almost straight and nearly horizontal line; the pre-mandibular portion is short, and is followed by a moderately long mandibular articulation behind which the border is sharply bent near the middle of its length to outline, as usual, the anterior limit of the post-mandibular region of the head. In this species, this is short and shallow; the removal of the gnathopod with its coxa uncovers the lower end of the cervical groove which clearly arises from this postero-ventral corner of the head. As in *brevicaudatus*, the transverse groove is complete dorsally, so that a maxilliped segment is well defined; the groove is, however, much weaker than in that species.

Peraeon. Again, as in *brevicaudatus*, the first peraeon segment is fused on to the head, of which it is less than one-half the length; the second to fifth segments are sub-equal, the sixth slightly, and the seventh decidedly, shorter; the width throughout the peraeon is fairly uniform.

Pleon. The first and second segments are both shorter than the seventh peraeon segment; the third is sub-equal to that; the fourth is almost as long as the sixth peraeon segment. The pleuron of the first is short, of the second longer (sub-equal to the depth of its segment), of the third and fourth deeper than the related segment, each of them meeting its related tergum in a nearly straight line behind. In the fifth, which is longer than the combined length of the third and fourth, the pleuron is deepest, its depth measuring nearly twice (?) that of its segment. The ventral borders of all these pleura are fringed with long, flexible setae which are continued up the hinder border of the fifth.

The pleopods hang down well below the lower ends of these pleura, the penial stylet of the adult male noticeable, being forwardly curved at the level of the endopodite, instead of hanging down almost vertically below the ends of the pleopods, as in *brevicaudatus*.

The *tailpiece* is barely as long as the fifth pleon segment, the terminal projection short and sharply upturned.

The telsonic pleuron has a slightly convex border, armed with a number of stout setae or slender spinules. These are usually eight in number and one of these, the fourth counting from above, is always stouter than the rest, thus agreeing exactly with Sheppard's description of this region in *C. tattersalli*.

The suture marking the junction of the sixth pleon segment with the telson, at the dorsal end of the articulation of the uropod, is short but distinct, and bears two long, stiff setae, agreeing with Sheppard's figure (1927, fig. 6 (11)) of *tattersalli*.

In front of the uropod, the pleuron of the sixth pleon segment has one stout distal simple spine, preceded by one similar but more slender, and this by four curved spinules, shorter and with a terminal toothed condition. There may be a slight variation here, some specimens showing *five* slender, toothed setae on one or both sides, but, apart from the slight numerical difference, they are markedly different from the condition described in *tattersalli* in that the curved toothed spines of *M. decipiens* are shorter (generally much shorter) than the stout distal spines, whereas of *tattersalli*, Sheppard states explicitly that they are longer. Finally, the telsonic apex differs from that of *tattersalli* and agrees with the

condition found in several of the Great Lake species (including *brevicaudatus*) in that the upturned end is armed with two *pairs* of spines and some eight to twelve scattered setae. It differs from *brevicaudatus*, however, in the angle at which it is upturned and in its shape. In *decipiens*, though slightly longer than broad, the projection is widest at its origin, whereas in *brevicaudatus* it is markedly longer and narrower relatively and its width decreases slightly near its origin.

Appendages. The *antennule* (fig. 55, *4*), in many examples, conforms almost exactly to the description given for *tattersalli*, but in some specimens *six* joints are found in the flagellum and the proportions of the several joints may then be quite different. Its length is nearly that of the peduncle of the antenna. In the female it is long, but there are only four joints in the flagellum.

The *antenna*, too, agrees sufficiently nearly with that of *tattersalli* so far as the peduncle and first joint of the flagellum are concerned; the number of joints in the flagellum is, however, somewhat variable (fourteen in the female; twenty-four in the male). The terminal joints scarcely exceed half the length of the first flagellar joint, whereas in *tattersalli* the terminal joints are said to be long, the penultimate being as long as the first. The appendage reaches a length slightly less than half that of the body.

The *upper lip* and *epistome* show the usual asymmetry, the notch for the right mandible palp being strongly developed (fig. 55, *5*).

The *mandibles* show the usual features, the principal and secondary dentate edges on the left bearing four and three teeth respectively, on the right mandible four; all are strong and heavily chitinised. In the palp, the second joint is by no means three times the length of the first, and upon this joint setae are present not only as a distal fringe, recorded for *tattersalli*, but also as a bordering fringe. Too much importance must not be attached, however, to the apparent absence or lack of record of such setae, as they are often to be seen only when the appendages are suitably mounted. Actually the arrangement of the setae in this species agrees closely with that of *tasmaniae*, although in previous accounts of that species, the bordering setal fringe has been neither recorded nor figured. Upon the distal half of the concave surface of the third joint of the palp is borne a row of short, simple setae, parallel to which is a row of shorter denticulate spinules. The apex is crowned by two or three longer, finely pectinate setae.

The *labium* (fig. 55, *7*) resembles rather closely that of *setosus*.

The *maxillula* (fig. 55, *8*) shows the condition characteristic of this genus, except that the outer endite is unusually long, but it differs from that described for *tattersalli* in a couple of minor details; the apex of the outer endite bears twelve spines and one small setospine and the marginal setae on both borders of the two endites are quite short. Two plumose setae spring from the posterior face of the outer endite.

In the *maxilla* (fig. 55, *9*), the only detail calling for special note is the number (eighteen) of the pectinate setae in the posterior row of setae fringing the mesial border of the proximal lobe, a similar number being found in *fallax*, whereas in *tasmaniae* there are about twenty-one and in *setosus* twenty-six.

The *maxilliped* (fig. 55, *10*) resembles closely that of *tasmaniae*, excepting that there are fewer (twelve only) brush setae on the dorsal margin of the endite.

The *gnathopod* of the male (fig. 56, *11* ♂) is, also, in close agreement with that of *tasmaniae*; the joints, however, are in general more setose and lack spines. In the female, too, there is a similar resemblance even to the narrow slots upon the palmar edge of the dactyl (fig. 56, *11* ♀), a feature which is absent in the male. Of the *peraeopods* generally the same is true. The fourth peraeopod of the male is stout, its joints heavily setose, the propod without strongly concave

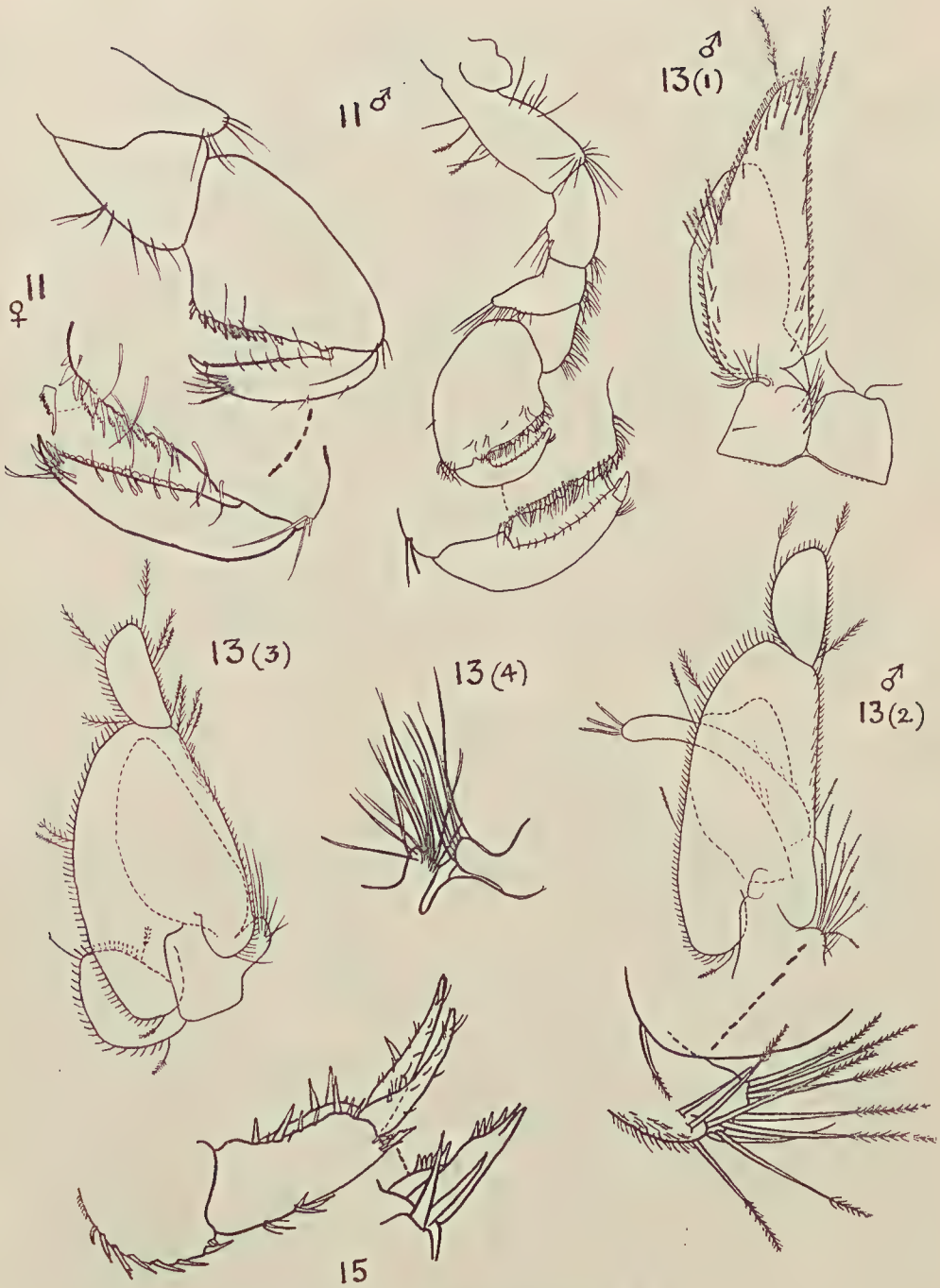


FIG. 56.—*Mesacanthotelson decipiens*, sp. n.

posterior margin (fig. 55, *12(4)*). The seventh (fig. 55, *12(7)*) seems to show an incipient flange on the posterior border of the basis, the enlargement making the maximum width nearly two-fifths of the length; in *tasmaniae* this is less developed.

The first *pleopod* (fig. 56, *13(1)*) is somewhat unusual in this genus, for there are numerous setae arising sub-marginally and sub-apically from the anterior face of the exopodite, in this resembling *brevicaudatus* and *Paraphreatoicus relictus*; the endopodite, though relatively rather shorter than in *tasmaniae*, is, nevertheless, longer than in the remaining species of this genus. The second pleopod has numerous entangling setae springing from the mesio-distal angle of the sympodite, the setae being doubly pectinate apically; proximal to these the surface of the sympodite is furred with short setules. In the male, the penial stylet is strongly curved and has three stiff setae apically, while its lateral border bears a few short setae or slender spines. In the succeeding pleopods the entangling setae are borne on strongly projecting lobes, and as these pleopods become more widely separated these lobes are increasingly elongated, the respective sternites being raised in a rounded boss in the middle line between the two entangling lobes. The epipodites are short, oval lamellae attached by moderately wide bases.

The *uropod* (fig. 56, *15*) is relatively short, its peduncle deep and longer than the rami, beneath the insertion of which are two stout, toothed spines of unequal length, flanked by two slender simple spines; the outer ramus has one spine.

Colour. In spirit, faded to a dull greyish brown.

Size. About 10 mm.

Occurrence. Great Lake, Tasmania; from stomach of trout.

This species seems to be nearest to *tasmaniae*, intermediate between that species and *fallax*, but in its lack of spines and the possession of abundant setae, approaching *setosus*.

Mesacanthotelson fallax, sp. n.

(Figs 57 and 58)

This species, also, is in appearance very like *M. tasmaniae*, from which it differs in the following respects; it is a much smaller animal, the body having the ridges less marked; spinose, but the spines considerably fewer and more widely spaced than in *tasmaniae*, and the rows tending to consist of a single, instead of a double, rank.

In the pleon, where mid-segmental ridges are scarcely developed, there are two rows of spines on the third, fourth, and fifth segments, the hinder sub-marginal, unlike the characteristic marginal fringe of *tasmaniae*.

The *head*—almost smooth and sub-equal to the combined length of the first and second peraeon segments—is *longer* than deep; the eyes, though prominent, do not appear in the profile of the head, so that the rather steep frontal slope starts directly from the anterior border of the head, which is but slightly emarginate.

The interocular area is little concave and not greatly wider than the longest diameter of the eye; it bears neither spines nor tubercles. The sub-ocular incisure is wide and shallow. The ventro-lateral border of the head appears as a smooth band, which runs above the mandibular articulation and widens into the lower (post-mandibular) part of the maxilliped segment from the hinder corner of which the cervical groove runs upward. This fails to meet its counterpart dorsally, so that the maxilliped segment is not there completely marked off from the rest of the cephalon, in this agreeing with *tasmaniae* and differing from *decipiens*.

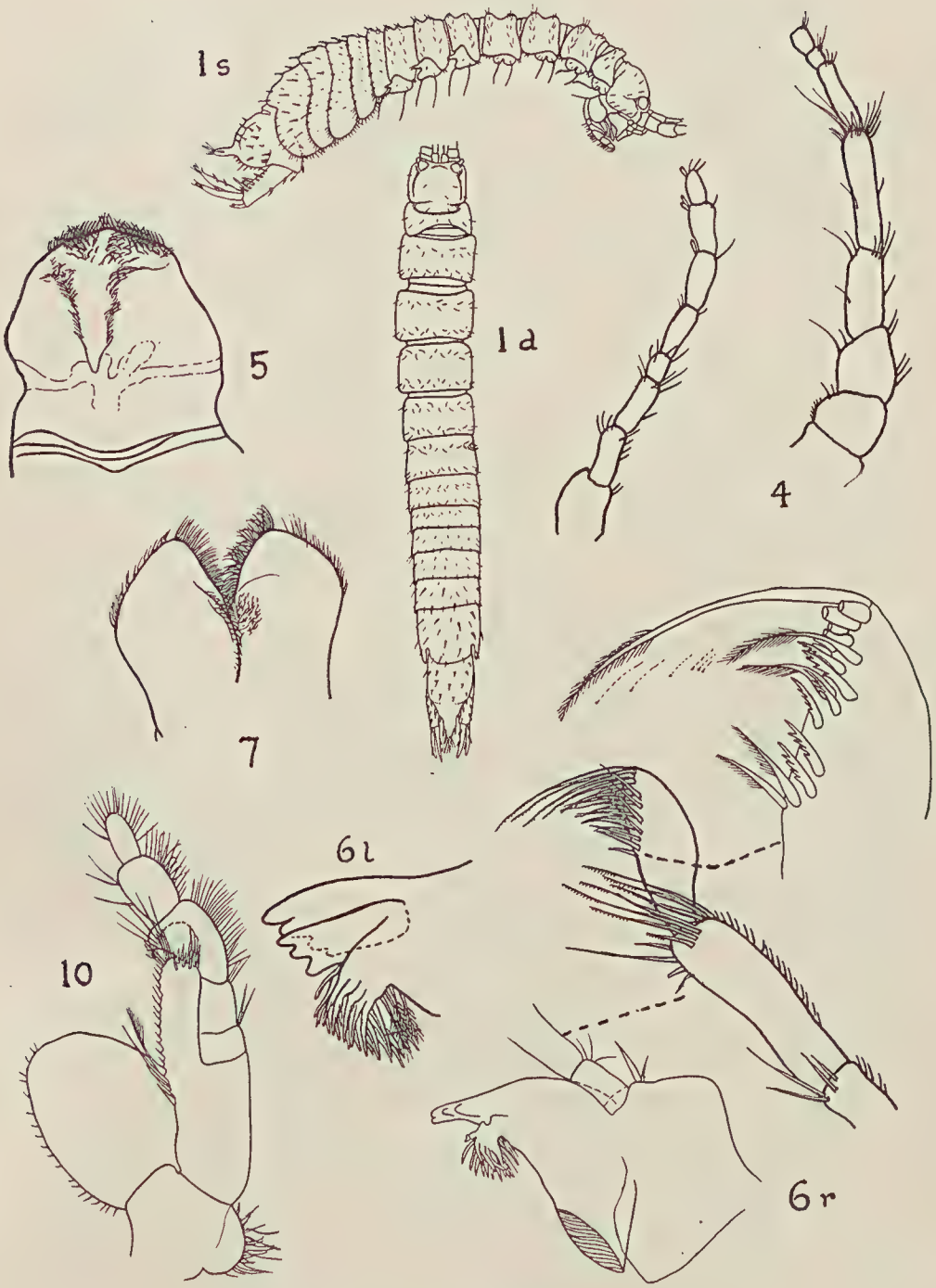


FIG. 57.—*Mesacanthotelson fallax*, sp. n.

In the peraeon, the anterior segments have a length sub-equal to the depth, except the first segment, which, although moderately long in the mid-dorsal line, appears short owing to the elevation of the tergum into a ridge which is preceded and followed by bevelled marginal areas. Ventro-laterally the segment seems to widen out, both anteriorly and posteriorly, slightly more than does the corresponding segment in *tasmaniae*. The second, third, and fourth segments are sub-equal; they are emarginate below for the articulation of the related coxae, in front of which they are angularly produced and bear one or two spines sub-marginally; the fifth to seventh peraeon segments are deeply incised postero-ventrally (as in *tasmaniae*) for the reception of unusually large coxae, so that the hinder border of the fifth and sixth segments are considerably shorter than the anterior; these anterior angles are unarmed; the posterior bear one or two spines.

The *pleon* generally differs very little from that of *tasmaniae;* the fifth segment, however, meets its pleura in a marked angle and—a more notable difference—the telsonic process is not only distinctly shorter, but when examined from above is seen to taper away evenly instead of standing out abruptly from the rest of the tailpiece. It thus appears sub-triangular when examined from above, recalling the shape of the projection in *Mesamphisopus* spp. It bears one pair of lateral spines sub-terminally and a second pair at the apex—these latter associated with a scattered tuft of long, slender setae. The telsonic pleura are slightly more convex than in *tasmaniae* and agree closely with the description and figure of *tattersalli.* In front of the insertion of the uropod the ventral margin of the sixth pleon pleuron is armed with four stout spines.

Appendages. Antennule and *antenna* (fig. 57, *4*) agree sufficiently well with Sheppard's description of *tattersalli,* making allowance for variation in number and size of the flagellar joints. The *second* flagellar joint of the antennule is *not* longer but is slightly shorter than the third peduncular joint; the antenna is distinctly less than half the length of the body, although the joints (twenty) are more numerous than in *tattersalli,* and the terminal flagellar joints, though long, fall considerably short of the length of the first joint of the flagellum while, in the peduncle, the fifth joint is shorter than the combined length of the third and fourth.

The *labrum* (fig. 57, *5*) appears longer and narrower than that of *tasmaniae,* and seems rather less asymmetrical.

The *right mandible* (fig. 57, *6r*) differs in several particulars; among these may be noted (i) the cutting edge shows the fourth tooth only in an incipient condition; (ii) the third joint of the palp appears more slender and is longer, relatively to the second joint; and (iii) its apical cluster of setae are arranged in rows of three or sometimes four; of the setae some are finely pectinate, others denticulate; there are more elongate setae apically and these are feathered. It thus differs considerably from the condition recorded for *tattersalli.* In *tasmaniae,* these setae are so closely bunched that it is difficult to discover their arrangement, and the terminal elongate seta of that species is finely denticulate. Fourthly, the spine row appears shorter and bears distally a couple of very short spines (or one bifid spine) which recalls the vestigial *lacinia mobilis* of *Uramphisopus pearsoni*; and lastly, there are more setae immediately proximal to the spine row than were found in *tasmaniae.*

The *left mandible* (fig. 57, *6l*) has four well-developed teeth in the primary cutting edge and three, almost equally stout, on the *lacinia.*

In the *lower lip* (fig. 57, *7*) there is no noticeable difference; the scales, so abundant on this structure in *tasmaniae,* are here almost as well developed.

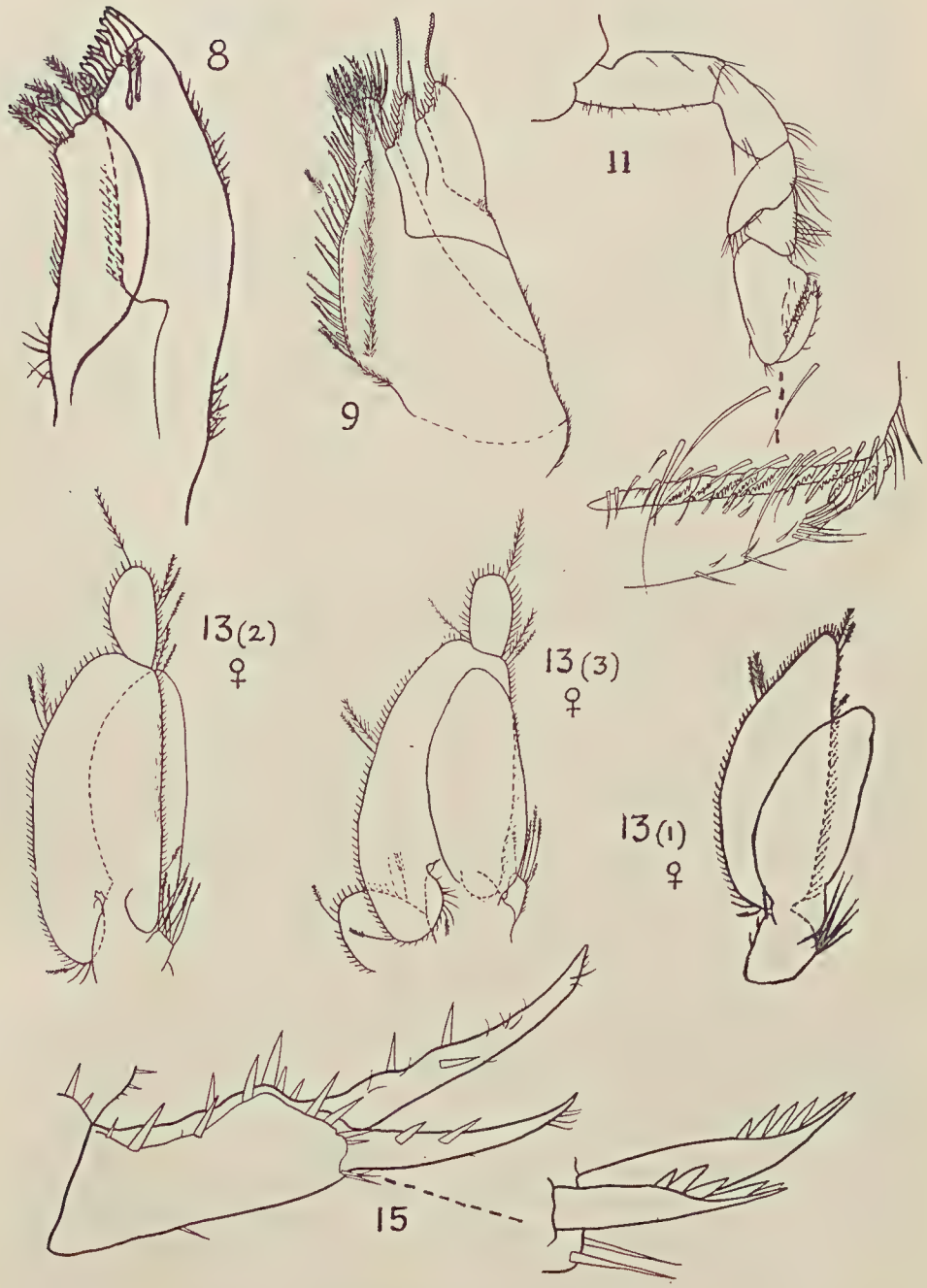


FIG. 58.—*Mesacanthotelson fallax*, sp. n.

The *maxillula* (fig. 58, *8*) differs from that of *tasmaniae* only in one minor detail of the armature of the outer endite. This is the presence of only two (instead of three) sub-apical plumed setae on the posterior face of this endite (in this apparently agreeing with *tattersalli*). There appear to be twelve simple or denticulate spines on the apex of this endite.

The *maxilla* (fig. 58, *9*) has an unusually long proximal endite, while the two outer endites are distinctly shorter than in other species of this genus. A continuous rank of short, simple setae on the anterior face of the proximal endite runs parallel to the filter setae.

The *maxilliped* (fig. 57, *10*), too, is relatively shorter and stouter, and generally rather less setose. The endite on the basis is more rounded apically and bears but fourteen or fifteen brush setae on its dorsal edge, while the more proximal fringe of simple setae appears to be wanting.

In the female, the coxal lobe is a semi-circular flap, edged by about twenty long, sparsely plumed setae, and rather fewer and more widely spaced stiff, simple setae.

The *gnathopod* is setose (in *tasmaniae* this appendage is armed with spines), but otherwise the various joints differ little except in the propod and dactyl (fig. 58, *11*). The former in the female is very nearly triangular in shape and the nearly straight palm more oblique and armed with fewer serrated spines. The dactyl is more setose but lacks on its palmar margin the notches or corrugations found in *tasmaniae*, *decipiens*, and *setosus*.

The *pleopods* (fig. 58, *13*, *(1)*, *(2)*, *(3)*) differ little from those of *decipiens*, except, perhaps, that in the second the endopodite is unusually long, extending to the base of the distal lobe of the exopodite. In the third, simple setae fringe the entire mesial border of the exopodite in both these species, whereas in *tasmaniae* such setae are restricted to the distal half of this border.

The *uropod* (fig. 58, *15*) is long and slender; the length of the peduncle is more than twice its greatest depth, the inner upper border little raised and with two distal spines on a low elevation; the outer border spinous along its entire length; the ventral edge is armed with two tufts, each including one spine and two or three setules, these restricted to the proximal half. The inner ramus is longer than the peduncle, with three stout spines; the outer ramus shorter by one-fourth its length and with but a single stout spine at its mid-length. Beneath the insertion of the rami are two stout, terminally digitate, spines.

Onchotelson, gen. n.

Body fusiform, tapering from the seventh peraeon segment; all segments with transverse ridges; head with deep anterior emargination, the interorbital space narrow, separating large and very prominent eyes; the cervical groove arises from the ventro-lateral border of the head and is complete dorsally, thus marking off a definite maxilliped (first thoracic) segment, while the second thoracic (first peraeon) segment is immovably united to the head; pleon segments little deeper than those of the hinder peraeon, narrow notch at junction of tergum and pleuron of the fifth pleon; telson short, sharply upturned; first and second pleopods modified in the male; the second endopodite two-jointed; uropods short, rami sub-equal with a single toothed spine below their insertion.

The rugose condition of the body is probably primitive; it occurs elsewhere in this sub-order in *Mesacanthotelson* and in a much reduced condition in *Eophreatoicus*, but in the former the ridges bear parallel rows of spines or stout setae,

while in *Eophreatoicus* neither spines nor setae are retained.[1] In the Phreatoicinae ridges are lost, but the arrangement of the setae persists. Prominent eyes, too, are found in *Mesacanthotelson*, but the retention of a complete cervical groove, and therefore of a recognizably distinct maxilliped segment, is almost peculiar to this genus. Among Phreatoicids it is found only in *M. decipiens*, but it is of interest that the development of a similarly well defined wedge-shaped first thoracic segment seems to have been characteristic of certain Carboniferous Syncarids (Pleurocaris, Gampsonyx?). The condition of the first and second pleopods in the male, likewise, is distinctive, the unusually elongated sympodite of the first pleopod recalling the condition of the pleopods in *Acanthotelson* in which, judging from Packard's restoration, the sympodite was sub-equal in length to the lamellae. The shape of the telsonic apex is reminiscent of that recorded for *Uramphisopus* and is quite unlike that of *Mesacanthotelson*; the sub-equality of the uropodal rami is unusual.

Genotype. *Onchotelson brevicaudatus* (G. Smith).

A second and quite remarkable species is recorded here under the name of *O. spatulatus*.

Onchotelson brevicaudatus (G. Smith)

(Figs 59 and 60)

Smith, 1909, p. 73, pl. 12, figs 5 and 6 *(Phreatoicus brevicaudatus)*.
Sheppard, 1927, p. 100, fig. 5 *(Phreatoicus brevicaudatus)*.

Smith's description was, as Sheppard notes, extremely brief; at that time, however, when but three Phreatoicids from the Great Lake were known, it was, with one correction, amply sufficient for the purpose of identification, and even now, his figures remain quite adequate for the recognition of this very distinct species. Sheppard, in attempting to remedy the deficiencies of Smith's description, has, unfortunately, allowed this mistake to pass uncorrected. Both authors have included in the first peraeon segment that of the maxilliped, which should be attributed to the head. With the discovery of many new Phreatoicids, however, a more complete description has become desirable, particularly for purposes of comparison.

The ridging and sculpturing of the *body* is practically as well-developed as in *M. tasmaniae* and *M. setosus*. In figure (59, *1s.*) an extreme condition is shown, the ridges on the peraeon segments attaining the maximum development. In the majority of specimens these ridges do not extend so far ventro-laterally and the areas beyond these are variably raised into tubercles or irregular, antero-posterior ridges. The existence of such irregular folding is suggested in Smith's figure (1909, pl. 12, fig. 5) and a more pronounced sculpturing is shown by Sheppard (1927, text-fig. 5 (1)). But this sculpturing can be even more strongly developed, so that at one stage in the preparation of this description a new variety *('sculptus')* was proposed for forms in which the setose ridges were limited to the dorsal surface and the whole of the lateral areas were raised into tubercles and folds and were almost free from setae. Such setae as were present were unusually long and slender, while in the pleon the lateral surfaces were practically smooth. Some support for the idea that this was a genuine variety was derived from the fact that when such extremely sculptured examples were taken, they were usually found to the exclusion of more highly ridged and setose specimens. A careful examination of a very large series, however, showed that there existed no definable

[1] *Protamphisopus* seems to have had much the condition found in *Eophreatoicus*.

boundary for the variety. The existence of the highly sculptured condition is, however, of interest in connection with the new species, *spatulatus*. The segments, with but two exceptions (the first peraeon and the sixth pleon), are raised into two well-marked ridges. It differs, however, from the two *Mesacanthotelson* species in that the armature is made up entirely of short setae which are set in double rows, and that spines are wholly wanting. It differs in shape, also, for, although the body of this animal is sub-cylindrical and (as in most members of this sub-order, when seen from above) fusiform, in the male it begins to taper posteriorly at a point unusually far forward (recalling *Amphisopus*). The body is widest in the second to fifth peraeon segments, then contracts markedly, so that the end of this region and the whole of the pleon is relatively slender, the width of the tailpiece not exceeding one-half of the greatest width of the body. Thus, although the depth of the pleon (i.e., the maximum depth of the body) is not apparently great[1] and only equals the greatest width of the body, it is nevertheless twice as great as the width of this region, a condition found in no other genus. It thus presents, to an unusual degree, the appearance of lateral compression.

The *head* (fig. 59, *2s*, *d*, *v*) is notable for several features: (i) in its proportions, its maximum width being greater than its length (again resembling *Amphisopus*) and equalling its greatest depth.

(ii) The eyes are very large and oval with many facets (fifty-eight to sixty) and are so prominent that they form part of the dorsal profile of the head. The ocular region is bounded by a conspicuous transverse frontal groove, behind which the convex dorsal surface of the head rises steeply, its profile with small irregular corrugations. The anterior border of the head is deeply emarginate (practically angular), its edge raised in a pronounced ridge. The interocular surface is concave but is commonly produced into a couple of short elliptical prominences, comparable to those found in *setosus*. The frontal part of the head is peculiarly narrow but somewhat variable, the interocular region ranging from a width little more than that of the longest diameter of the eye to one which approaches twice that diameter.

(iii) The sub-ocular incisure is a shallow notch, wide but short, below which the sub-ocular area, though strongly projecting, is not well defined nor is the 'genal' groove complete. The mandibular portion of the ventro-lateral border is relatively well marked and the mandibular articulation long, while the post-post-mandibular region is shorter and deepened; the ventro-lateral border is indicated by a slight ridge bearing a marginal rank of setae.

(iv) The head is almost unique in this sub-order in that the cervical groove is *completed dorsally* so that the maxilliped segment is visibly distinct from the more anterior part of the head. Behind, a wider intertagmal groove marks off the cephalon from the peraeon. These two grooves approach closely at a point beneath the forwardly projecting coxa of the gnathopod (fig. 59, *2s*) the maxilliped segment then widening out below into the post-mandibular region of the head. It would seem that Miss Sheppard (1927) has followed Smith in misinterpreting this region, the dorsal part of the maxilliped segment being represented as constituting part of the *first peraeon segment*. The first peraeon segment is so firmly fused with the head that there is no mobility here, but there can be no doubt that the boundary between primary head and peraeon lies *posterior* to the

[1] The pleon segments are little deeper than the hinder peraeon segments and the pleopods are often exposed to an unusual degree. In the figure (fig. 59, *1s*.) these have been omitted, but their length can be judged by that of the penial stylet which only exceeds by a little that of the second pleopod.

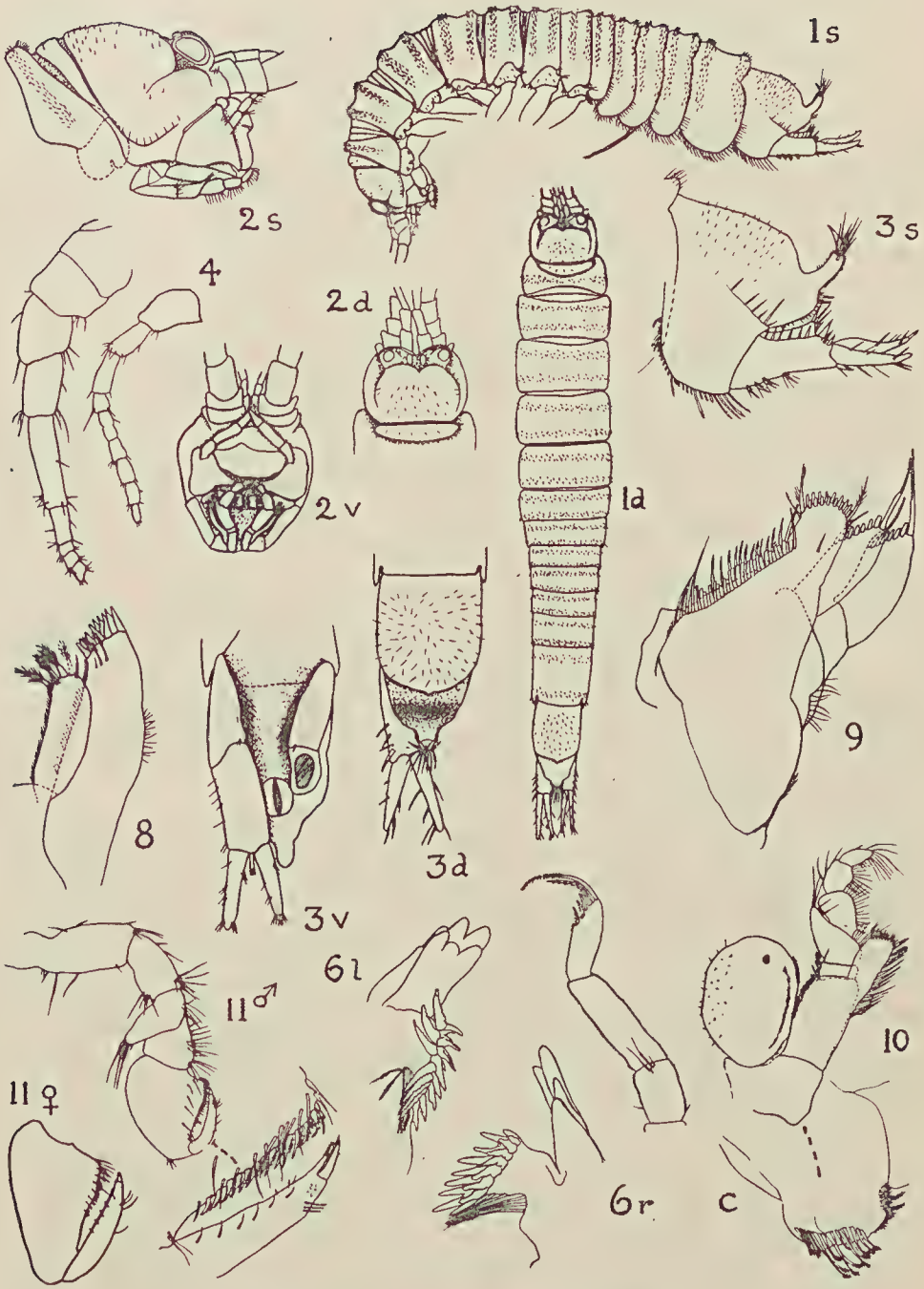


FIG. 59.—*Onchotelson brevicaudatus* (G. Smith).

first of the two ridges shown on the first peraeon segment of Miss Sheppard's figure (l.c., fig. 5 (i)). In actual specimens, this boundary is unmistakable, the groove being much wider than represented in that figure, and presenting an appearance of the usual bevelled edge of a free segment. In the male figured (fig. 59, *2s, d*) the two grooves (cervical and post-cephalic) appear relatively wide.

It seems probable that this transference of the maxilliped segment from the head to the first peraeon segment is responsible for the mis-measurement recorded in the statement 'the cephalon is shorter than the following segments'. Actually the head (measured in the mid-dorsal line), notwithstanding its considerable shortening by the exceptional depth of its anterior emargination, is *longer than any one of the peraeon segments.* It is more than three times as long as the first peraeon segment and is little less than the combined length of first and second peraeon segments.

Peraeon. The first peraeon segment is immovably united with the head; it is very short dorsally and bears but a *single ridge*, but ventrally it is widely expanded and extends forwardly to embrace the hinder angle of the head. In its strongly concave anterior and posterior borders (fig. 59, *1d.*), this segment has a condition like that of *N. assimilis.* On the ventral surface, the sternite is slightly raised along its anterior border into a ridge, against which abuts the coxa of the maxilliped.

Of the succeeding segments, the second to sixth are sub-equal; the seventh is considerably shorter.

Pleon. Not only is this much narrower than the peraeon, but the downward extension of the pleura is relatively slight, so that there is an unusually small increase in the depth of the body in this region. The fifth pleon segment is notable, not being as greatly elongated as is usual in this sub-order; it has a length scarcely equal to the combined length of the third and fourth, and its hinder border meets its pleuron in a sharp notch. In all the pleon segments the pleura are fringed ventrally by long, flexible setae, but these are continued well up the hinder margin in the fifth pleon segment alone.

The *tailpiece* (fig. 59, *1s, 1d, and 3s*), distinctly longer than the fifth segment, has a convex dorsal surface, the terminal projection being sharply upturned, the telson thus appearing hook-like. Its apex is armed (fig. 59, *3s, d*) with a tuft of long setae and two pairs of spines, but, behind, it presents a flat postero-ventral surface. In side view it passes almost imperceptibly into the telsonic pleura which bear marginally a few short setae or spinules. The antero-ventral border of the tailpiece, that is, the pleuron of the sixth pleon segment, bears a series (twenty to twenty-five or more) of long, curved and close-set setae, of which a variable number, mostly shorter setae *at the anterior end of the fringe*, are toothed apically. Such a long rank of setae is peculiar to this genus—this condition being most nearly approached in *N. littoralis* and *M. australis*, where, however, the setae are replaced by spinules and are less numerous.

Appendages. The *antennule* (fig. 59, *4*) in the males examined had usually but five joints in the flagellum, only one agreeing with Sheppard's record of six, but that specimen showed an approaching division of the second flagellar joint to give an incipient seventh article. In the mature female, there were but four, of which the second and third were long. In the *antenna*, also, fewer joints were found in the flagellum than are recorded by Sheppard.[1] There is probably, as in

[1] Thirteen to twenty, with an average of sixteen (male) and fifteen (female) respectively; the specimens examined may not, however, have reached full growth.

M. tasmaniae, a considerable range of variability in the number of flagellar joints and no diagnostic value can be attached to this character. The peduncle is robust and very little shorter than the flagellum, in this retaining what may, perhaps, be a primitive condition; the proximal four joints are relatively short and subequal, the fifth, alone, being elongated.

The 'serration' in both antennule and antenna, of the joints of the peduncle and of more or fewer joints of the flagellum, to which Smith referred, and which Miss Sheppard more correctly records as a covering of 'short, thick hair', has already been recorded in *Eophreatoicus*. In this species it occurs not only in the antennae but forms a clothing for practically the whole of the body and the appendages.

Upper lip (fig. 59, *2v*, fig. 60, *5*). The epistome is very strongly projecting, the whole structure stout and the hinge of labrum on epistome noticeably asymmetrical. The labrum is wide and shallow; upon its under (posterior) surface the ventral fringe of setae is extended upward, in two converging bands, to meet nearly at the level of the suture with the epistome.

In the *left mandible* (fig. 59, *6.l.*) the secondary dentate piece *(lacinia mobilis)* bears three teeth almost as strong and as darkly chitinized as the three large teeth of the primary cutting edge, on which a small fourth tooth is indicated. The spine row is unusual in its structure and is followed by a short rank of five slender, plumose setae. As in *Eophreatoicus* and some New Zealand species, the palp arises from a slight elevation which is armed with setae, its second joint being nearly twice as long as the first or third. The latter is obliquely truncated and bears a terminal finely-plumed seta preceded by a short row of five strongly denticulated setae decreasing in length proximally; there is here, probably, the maximum reduction of this setal armature of the mandibular palp.

The *right mandible* (fig. 59, *6.r.*) differs slightly in having four stout teeth on its dentate edge, in the absence of the *lacinia mobilis* and in the disposition of the spine row.

The *labium* (fig. 60, *7*) bears setules on the outer border, as well as the usual heavy fringe of setae on the inner border of the terminal lobe. There is a small indication of an inner lobe.

The *maxillula* (fig. 59, *8*) has nearly attained the maximum reduction in the number of apical setospines on the inner endite. Only four are present and the two accompanying simple spines are very slender, one outermost, the second lying against the third setospine; while the endite itself is both short and narrow. The outer endite bears the usual double (partly triple) rank of stout spines; mesially some of these are strongly denticulate and there is the usual small setospine near the mesial edge of the posterior surface. There are three slender setae, also, on the same face, two plumose, the innermost small and simple. The fringe of short setae may be greatly reduced or even absent on the outer aspect of this endite, but the inner mesial border of both endites has a continuous fringe of setules.

Maxilla (fig. 59, *9*). In this appendage, the mesial surface is narrow; the posterior row of about nine finely pectinate setae appears to be marginal and the anterior close-set row of long, filter setae is borne slightly sub-marginally. The latter series comes to an end, distally, on the anterior face of the proximal endite, the usual single spine lying lateral to this point. A short unarmed region separates the distal end of these two mesial rows from a double apical row of setae which are biting or plumose, or may be intermediate in character.

The two distal endites are short, their end obliquely truncated, and armed with few (six to eight) biting setae, which on each endite become increasingly stouter laterally. There are a few setae on the outer (lateral) border.

Maxilliped (fig. 59, *10*). This agrees generally with Miss Sheppard's description. The coxa is wide and, in the ovigerous female, its mesial process is indistinctly bi-lobed and bears sub-marginally a number (fifteen to seventeen) of stout, strongly-curved setae, scantily plumed apically, mixed with which proximally are a few more slender, simple setae, while distally, there are one or two short, densely-plumed spines, buried in a tuft of short setae which are continued after a brief gap by a dense fringe of setae at the proximo-mesial end of the basis. Its condition would appear to be closely comparable to that recorded by Sheppard for *tasmaniae* (1927, p. 90), but of that species no ovigerous female was available for examination. The latero-distal angle of the basis bears two stout, plumed spines; the endite of the basis is rather long and carries, on the distal half of its free edge, a rank of twelve brush setae; these pass into an apical border of shorter, more sparsely feathered setae. The length and the number (eleven to nineteen) of the setae fringing the epipodite is somewhat variable.

The *peraeopods* are all relatively shorter and stouter than in *tasmaniae*, but unlike that species, they are almost devoid of spines, so that, in this particular, *setosus* offers an intermediate condition.

The *gnathopod* of the male (fig. 59, *11* ♂) is strongly built; the basis is short and the ischium is moderately long; the propod is stout, sub-triangular in shape, its anterior border convex, the posterior short, the slightly sinuous palm disposed obliquely and armed with about a dozen stout, curved spines (strongly toothed on the convex surface) and with a parallel row of setae. The dactyl is long, strongly curved and bears apically a stout claw supported by a small secondary unguis; its palmar surface bears a few short, curved setae.

In the female, the limb is relatively short, the basis being shorter and rounder than in the male, the propod (fig. 59, *11* ♀) sub-triangular, not strongly developed, its palmar border appearing so thin as to be almost knife-edged, but produced into a few spines which resemble those in the male; the dactyl is less strongly curved, its inner distal border minutely denticulate.

The brood lamellae are fringed with a fairly close-set rank of setae, some of which, at least at the proximal and anterior end of the lamellae, are feebly plumed apically. The functional lamellae are very long, being, with the exception of the first pair, considerably longer than the related limbs.

In the male, the strong, curved dactyl and small concave and spine-bearing palm on the propod of the fourth leg suggests that this limb is sexually modified and strongly prehensile.

Of the hinder group of *peraeopods*, the fifth is short and relatively weak, the sixth and seventh sub-equal. The basis in these hinder appendages (fig. 60, *12(7)*) is stout but not appreciably expanded; the ischium about as long as the slender propod. In the female, if the coxa of the fifth be removed with the limb, a long, ridge-like strip may tear away from the sternite, perhaps representing a vestigial and fused oostegite. The oviducts seem to open below this ridge near to its lateral end. In the male, the penes are related similarly to the coxa of the seventh peraeopod; they are apparently wholly unarmed, relatively long, meeting in the middle line near the distal end of the sympodite of the first pleopod (fig. 60, *12(7)*).

Pleopods. In the condition of the first pleopod (fig. 60, *13(1)*) this species has no parallel in the family. The sympodite, sub-quadrangular in shape, is a massive-looking structure, much longer than those of the succeeding appendages,

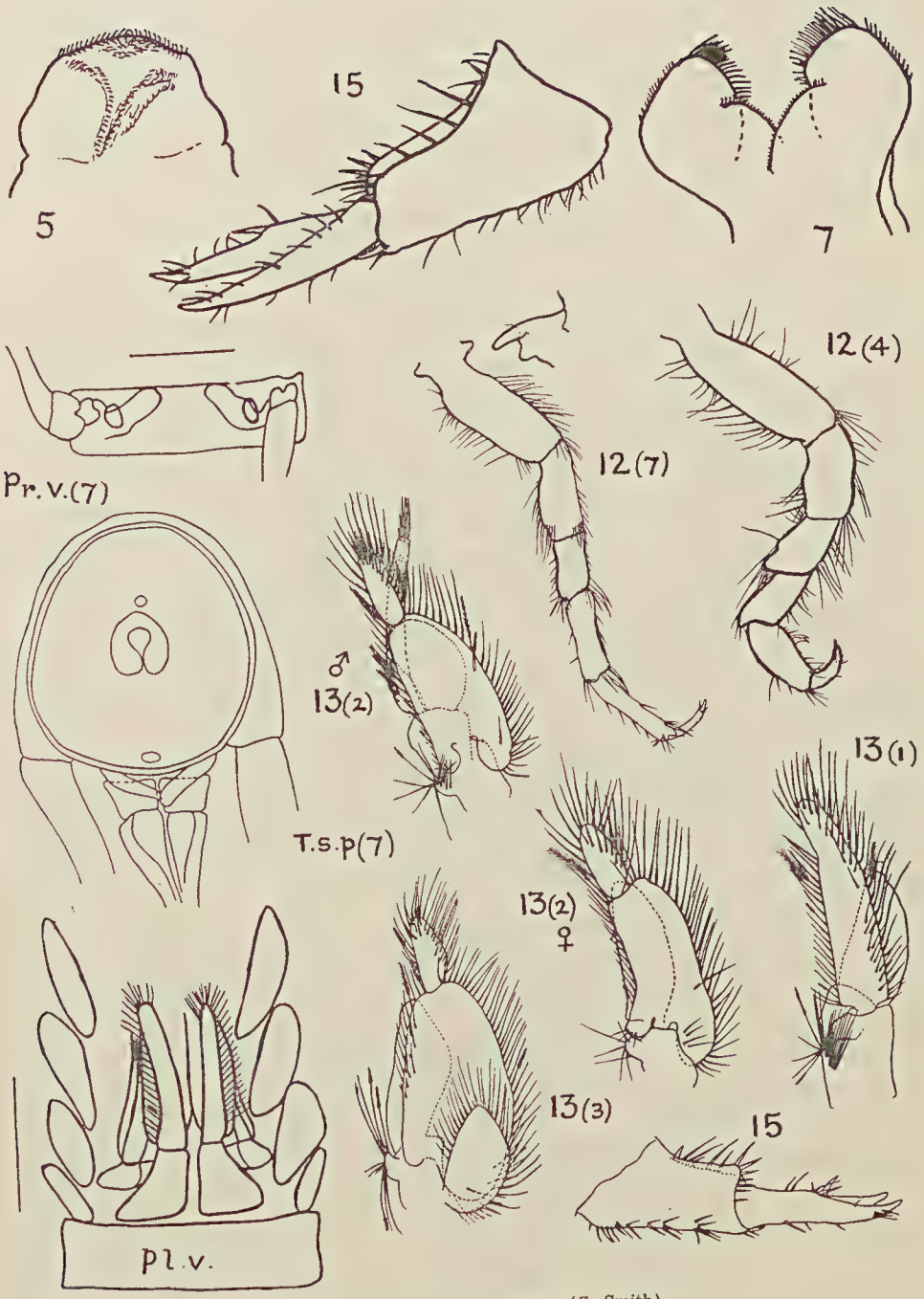


FIG. 60.—*Onchotelson brevicaudatus* (G. Smith).

and thick from front to back, and, in front of the exopodite, is produced distally into a small flap. The appearance of solidity is increased by a large, thickened proximo-mesial portion of the exopodite (fig. 60, *pl.v., t.s.p.(7)*); further, the two lamellae seem to be borne obliquely so that both exopodite and endopodite appear when viewed from in front. These lamellae arise from the sympodite at different levels. The endopodite springs from its inner border, about midway along the length of that piece, whereas the exopodite has its origin practically from the apex of the sympodite.

The entangling setae arise in three steps, the most distal being almost marginal; the setae are numerous and some at least are minutely denticulate.

The exopodite is moderately well developed but, owing to the unusual length of the sympodite, appears relatively short, being in some specimens (male) little more than twice the length of the basal region. In shape, it is narrow, lanceolate; the apical portion is almost brush-like and may represent the distal lobe of succeeding limbs, being bent at an angle to the more proximal part. This condition is found in nearly all specimens examined, of both sexes, and cannot therefore be regarded as a distortion due to the position and unusual length of the penial stylet. It is fringed around its entire border with long setae which are plumose in the distal third of the mesial, and the distal half of the external border. Under close scrutiny, the densely setose or brush-like condition of the free end is discovered to be due to the fact that two, in places three, ranks of plumose setae arise in steps marginally and from the anterior face of this lamella, and this step-like arrangement is continued along almost the entire lateral border. A somewhat similar condition is found in *U. pearsoni*, while in West and South Australian species, and also in South African forms, there is a similar sprouting of setae from the anterior surface, but in those other species the setae seem to be scattered irregularly, are usually fewer and generally are simple only.

The *second pleopod* is longer than the first by half the length of the distal joint of the exopodite. In the male, the sympodite is moderately long, its inner distal angle being produced mesially into a stout process bearing the entangling setae, which are numerous and spring both from the inner border and, much more proximally, from the hinder face of the sympodite. These setae are fewer in the female.

The endopodite is distinctly two-jointed; the basal lobe is very muscular and nearly as large as the respiratory portion of the lamella; from its disto-mesial angle arises the penial stylet, while laterally it is expanded into a sub-oval, rather swollen, respiratory lamella, which extends distally to the base of the distal lobe of the exopodite. The stylet is exceptionally long, hanging ventrally quite freely below the general level of the pleopods, in which elongate condition it resembles *orarii*. Proximally, on its mesial border, it bears six or seven short spinules, while, sub-apically, there is a graduated series of seven long stiff setae, some minutely denticulate or pectinate; its surface is clothed with minute setules. In the female, the endopodite is longer, relatively, but a basal lobe is not differentiated. The exopodite is similar in both sexes, the basal part being produced *proximally* into a small inner and a larger outer lobe lying partly behind the sympodite. There is a difference, however, in the setation. In the male, the marginal plumose setae are found with the distribution generally like that of the first pleopod. In the female, the inner border of the proximal lobe has no plumose setae, their place being taken by setae which are pectinate terminally.

In this and the succeeding appendages, the condition of the distal joint of the exopodite is again without parallel in other Phreatoicidae, the apex of the distal joint being brush-like, bearing a number of long plumose setae arising from the anterior face of the lamella, as well as furnished with bordering setae. There are here, too, delicate sub-marginal, simple setae laterally along the distal part of the proximal joint, and a few longer setae arising from the face of the proximo-lateral lobe.

In the *third pleopod,* the pectinate entangling setae are seen springing from the inner border of a large process projecting mesially from the distal end of the sympodite, and both the exopodite and the endopodite of the third are longer and wider than those of the second pleopod. In the hinder pleopods, the lamellae are shorter and only relatively wider. The epipodites are large, sub-ovate, and closely fringed with long, simple setae. The entangling setae become fewer, the projection from which they arise being quite long. A few setae are found on the anterior face of the proximo-lateral lobe.

In the pleopods generally, the whole or part of the mesial border of the exopodite is thickened and stiff setae arise, not only marginally but in a dense sub-marginal fringe. Such a mesial sub-marginal fringe extends along the whole length of the inner border of the first and second pleopods, but in the succeeding limbs the setae are restricted to the distal part of this border. Along the curved outer border and around the distal lobe, the lamella is fringed with uniformly-spaced, long, flexible setae, some of which (the more apical only) are plumose, the remainder pectinate or simple.

Uropod. This is unusually short[1]; the length of the peduncle measured along its upper border is scarcely greater than its depth at its oblique insertion. In dorsal view, the peduncle broadens distally; this appearance is enhanced by the fact that ventrally the tailpiece in inturned,[1] so that the two uropods are somewhat approximated; in the ventral view (fig. 59, *3v.*) it may be seen that when the limb is removed its attachment is comparatively narrow and long, though foreshortened in this view. The dorso-mesial edge of the peduncle is raised very slightly above the level of the outer edge and bears only two or three apical spines, but from these a short row of spines (fig. 60, *15*) runs downwards towards its lower mesial edge. The outer edge has a series of setae and one stout distal spine; the ventral border appears to have a nearly continuous line of setae, but actually these arise chiefly in short rows on the mesial surface and project mesially. The rami are styliform, tapering and sub-equal and each bears one spine and a few setae only; beneath their insertion is one relatively long and stout spine, toothed apically. In the female, the peduncle is shorter and thus appears deeper and there is less difference in the length of upper and lower borders.

The telsonic projection is short and smoothly upturned, and is rather longer than broad. Its actual extremity is dorsal in position and bears a pair of terminal spines and a second pair latero-terminally, as well as numerous fine setae. The margins of the projection bear a fringe of fine setules. Postero-ventrally there is a smooth surface which lies behind the last sternite. The telsonic pleura, though slightly developed, nevertheless extend almost as far back as the projection when viewed from above. On the last sternite, the anal opening is directed ventrally. A typhlosole is present (fig. 60, *T.s.p.(7)*), and may be traced forward from the fifth pleon to the first peraeon segment. At that level it is enlarged and is seen as a paired structure, apparently part of the gastric mill.

(1) The uropod is even shorter in *Phreatoicopsis* and *Protamphisopus* and the telsonic pleura are even more inturned in *Phreatoicopsis.*

Colour. Geoffrey Smith records this as straw-yellow in life, which is the usual colour of spirit-preserved material, although in time, this may become greyish or greyish brown.

Size. The largest specimens may reach 15 mm.

Occurrence. Great Lake, Tasmania, 'in the deeper littoral where the bottom is chiefly composed of a fine yellowish mud'. (G. Smith.)

This species has, hitherto, been the only one recorded from the bottom of the Great Lake. It is of interest that *U. pearsoni* which resembles *brevicaudatus* in the shape of the telsonic projection, is also, in all probability, a dweller in this same muddy floor of the lake. Specimens of this latter, however, have never apparently been taken in the dredge, and only rarely in the stomach of trout, where they are generally covered with yellow-brown or reddish-brown mud. The capture by Dr. Pearson of a second and quite distinct species of *Onchotelson* provides, therefore, a notable addition to our knowledge of this part of the fauna of the Great Lake.

Onchotelson spatulatus, sp. n.

(Fig. 60A)

This new species, while indisputably referable to *Onchotelson*, differs not only from *brevicaudatus*, but from all known Phreatoicids in the development of strong processes from the coxae of all the peraeon appendages, strikingly suggestive of epaulettes. It is this condition which has led to the choice of name.

Apart from this striking feature, it differs from *brevicaudatus* in other external characters, only in degree. As seen in fig. 60A. *1s*, the head (which is shown without appendages) is rather more corrugated and tuberculate; its cervical groove is clearly defined and the maxilliped segment thus retains its distinctness from the primary head. In the peraeon, transverse tergal shields are raised above the level of the general surface of the body, leaving smooth and bevelled strips anteriorly or posteriorly. The segments, moreover, have well-developed ridges, comparable to those setae-covered elevations characteristic of *brevicaudatus*, except that here they are short and restricted to the dorsal surface, being in this respect closely like the condition noted above for the variety which is referred to as '*sculptus*'; on the lateral surfaces these ridges are obsolete and are replaced by tubercles and irregular folds; even the ridges appear to be made up of a series of coarse tubercles. On these surfaces the sparsely scattered setae are long and slender.

Only four specimens were available and all of these were in a greatly relaxed condition, so that the intersegmental membranes are unusually conspicuous. In general, the proportionate length of tagmata and of individual peraeon segments are much as in *brevicaudatus*, but the segments are relatively shallower.

In the pleon, however, the terga appear somewhat deeper, and the pleura therefore are by comparison less deep; the fifth segment, too, is relatively shorter, while on the tailpiece the telsonic apex seems rather more sharply upturned, and, as in *brevicaudatus*, this is armed apically with two pairs of spines and numerous setae, for the most part long and flexible. The armature of the ventral border of the sixth pleon segment, too, resembles that of *brevicaudatus*, with a number (twenty or so) of slender, curved setae, while the junction of the sixth pleuron with that of the telson is indicated by the usual short ridge bearing three or four setae.

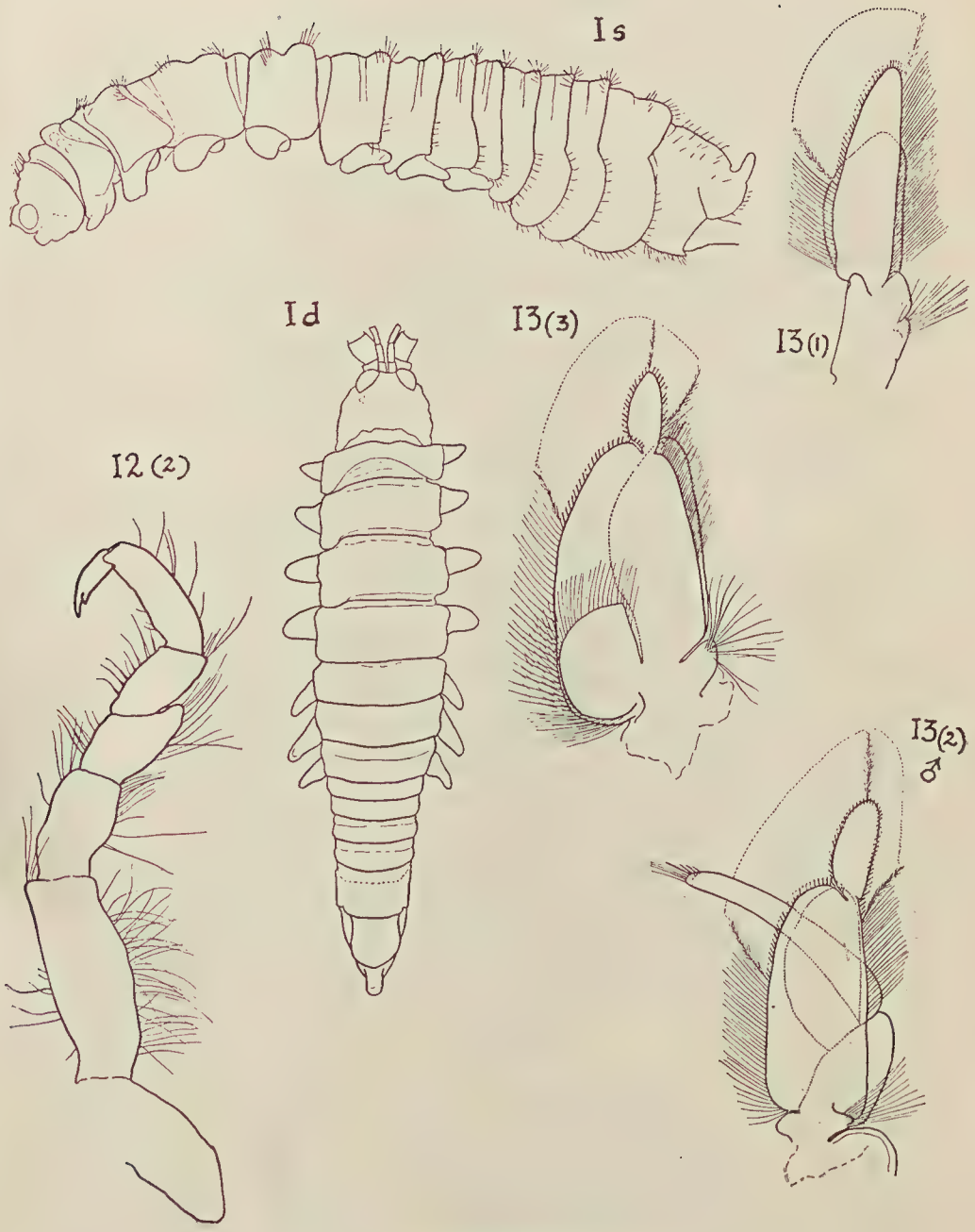


FIG. 60A.—*Onchotelson spatulatus*, sp. n.

As figured in dorsal view (fig. 60A, *1d*) the fusiform shape is evident, but that outline is broken by the seven pairs of coxal processes. It should be noted that in this figure the relative lengths of the segments are not quite accurately shown, the body of the animal being strongly curved, the head and part of the pleon being shortened; the width is greatest in the third and fourth peraeon segments, where it attains to almost exactly one-sixth of the total length.

Appendages. Of the four specimens, all male, which were taken, but a single example was dissected. In structure the several appendages showed generally a very close resemblance to the typical condition of a male *brevicaudatus* of about the same size. A few, comparatively trivial, differences are noted.

The *antennule* seems more slender, particularly the second peduncular joint; there are, also, small differences in the proportions of the five joints of the flagellum.[1] As in *brevicaudatus*, the condition of the second joint of the peduncle of the *antenna* suggests that it may have arisen from the fusion of two articles, and the proportions of the peduncular joints differ slightly from those of *brevicaudatus*. The actual end of the flagellum was lost, but the appendage appeared nearly complete, with fourteen joints, of which some (from the eighth onwards) are distinctly longer and rather slender.

In both *mandibles*, the terminal joint of the palp shows a similar paucity of setal armature, but on the first and second joints setae are rather more abundant. The inner endite of the *maxillula* is in close agreement with that of *brevicaudatus*, a strong, simple spine being present,[2] as usual, against the third setospine; on the outer endite of one side, however, a rather unusual condition is found, the sub-terminal plumose setae on the posterior face being two in number, unusually long and arising close to the mesial border; upon the opposite appendage these were apparently wanting. Among the terminal group of spine-teeth there is, as usual, one setospine which, in the specimen examined, was exceptionally well developed, but setae were restricted to its mesial face. The *maxilla* shows the mesial rank of filtratory setae extending very far distally, while the setae which make up the rank are relatively short as compared with the pectinate setae which support it. The usual single spine on the face of this endite could not be discovered. The *maxilliped* is short, but shows the same relatively long coxa seen in *brevicaudatus*, and an unusually stout and conspicuous plumose spine at the latero-distal angle of the basis, which is considered as representing a vanished exopodite.

On the peraeon, as already noted, all the appendages show the coxa produced outwardly into a flattened spatulate process. Under the microscope the process is seen fringed with, presumably covered by, a dense fur of setules, while stray hair-like setae spring from the free surface. Otherwise, these appendages seem to resemble closely those of *brevicaudatus*, excepting that the anterior border of the basis of the first four and the posterior border in the case of the hinder three is more heavily fringed with setae, which are, as usual in this species, long and hair-like.

In the *gnathopod* the palm is armed with about thirteen slender denticulate spines and numerous other setae and spinules; the merus is strongly produced and bears a dense rank of stiff setae. In the next three *peraeopods* the basis differs somewhat in its proportions and the ischium is perhaps slightly longer, relatively. The propod of the fourth peraeopod is stouter and its palm rather more spinose; the seventh peraeopod displays a different arrangement of the setae upon the ischium.

---

(1) Six in some examples. (2) Not shown in figure 59, *8*.

Upon the seventh sternite a stout, doubly-curved ridge is developed, against which lie the paired male appendages. This is present in *brevicaudatus* also, although attention was not called to it in the description of that species. Such a ridge is developed on no other sternite, and it is probably related to the functioning of these appendages, the free ends of which lie normally against the apices of the sympodites of the first pleopods.

The pleopods, too, differ little from those of *brevicaudatus*. In the first, the sympodite is relatively rather less stout; the flap arising from it latero-distally, which may well be a reduced epipodite, is much smaller than in *brevicaudatus*, but its occurrence seems to be a generic character. Mesially, on the exopodite of the second pleopod, the setal fringe appears even more dense, extending in from the margin well onto the lamella, but apically the brush-like condition is less strongly developed; the penial stylet carries eight terminal stiff setae, graduated in length, but only one of the proximal spines, near the mesial border of the stylet, could be made out. A large swelling on the sternite separates the paired sympodites of the second pleopods. On the third pleopod, the principal difference appeared in the shape of the coupling lobe.

In the *uropod* differences were few and slight. Upon the inner border of the peduncle the apical projection is rather higher; a stout spine marks the end of the outer border; the outer ramus is slightly shorter than the inner, both rami bearing a single spine at or near mid-length.

Size. About 13 mm.

Colour. Pale straw colour, becoming greyish in parts.

Occurrence. Taken in April, 1939, in the Great Lake by Dr. Pearson.

Colacanthotelson, gen. n.

Body fusiform, segments with setose transverse ridges moderately developed; eyes fairly large and prominent; telson scarcely upturned, rounded, relatively short with four (or two?) spines apically; the sixth pleon pleura with few (five or six) slender, curved spines; pleura of telsonic region with seven to ten spines or spinules, of which one (third or fourth) below the telson is longer and stronger than the others.

The genus was proposed in the first place for the reception of the Kosciusko species. From a consideration of Miss Sheppard's figures (1927, fig. 6) as well as her description of *tattersalli* from the Great Lake, it appeared that this Tasmanian species, also, ought to be included here. In the absence, however, of actual material of that species, it has seemed desirable to include it in the genus Colubotelson, with the species of which it has perhaps still more in common.

Genotype. *Colacanthotelson rugosus*, sp. n.

Colacanthotelson rugosus, sp. n.

(Figs 61 and 61A)

Amongst the Phreatoicid material provided by Prof. Chilton were several examples of *M. australis*, one of which differed quite noticeably from the rest. Later, in generous response to a request for additional material of *M. australis* (Chilton), about a dozen specimens were sent by Dr. Anderson, then Director of the Australian Museum, Sydney, and included in this material were two other

specimens resembling the stray example in Chilton's material. A detailed study proved it necessary to institute for these, not only a new species, but also a new genus, exhibiting affinities with *Mesacanthotelson*.

The body is characterized by a marked rugosity, the ridges being set with setae in a fashion recalling the condition of *O. brevicaudatus*, though less extreme.

The *head* (fig. 61, *2s*) is long and narrow, the eyes oval, large and prominent, their dorsal border modifying the profile of the head; there is a shallow sub-ocular incisure and a strong cervical groove which is incomplete dorsally.

The first *peraeon* segment appears short and greatly expanded ventrally; the third peraeon segment is longest, as long as its greatest depth; the fifth to seventh segments become progressively shorter; the seventh is deepest.

The first *pleon* segment is about two-thirds of the length of the last peraeon segment and slightly deeper; the second, third, and fourth are sub-equal, the fifth as long, nearly, as the combined length of the first three pleon segments, but rather shallower. In the peraeon, both antero-ventral and postero-ventral angles bear a few setae, while the pleon segments have a ventral fringe of long setae which is continued half way up the posterior border. The *tailpiece* is as long as the combined length of second, third, and fourth pleon segments, and is produced into a moderately long and narrow telsonic apex, armed with a pair of spines and a tuft of setae terminally, and a second pair at a node some way back from the end, in a manner reminiscent of *M. tasmaniae*. Apart from the telsonic apex, the tailpiece is quite distinctive. Its anterior border dips steeply to a narrow ventral edge which bears five slender, curved spines, terminally digitate, these spines becoming progressively stouter posteriorly; at the end of this border are two stout, simple spines, and immediately dorsal to the last, two short furcate spinules. The free posterior border of the telsonic pleuron is armed with seven evenly-spaced spines, of which the third from the top is stoutest; immediately sub-marginal (anterior) to it is a second stout spine. There is a distinct ridge running antero-dorsally from just above the insertion of the uropod, and this, again closely paralleling the condition of *M. tasmaniae*, bears two spines (three on one side in one specimen).

The *antenule*, in the one complete appendage, had a flagellum in length sub-equal to peduncle, with six joints, which are slender and not swollen.

The *labrum* (fig. 61, *5*) shows a marked asymmetry, the incisure occupied by the right mandibular palp being relatively deep.

The *right mandible* (fig. 61, *6r*) is noteworthy for several features; the four teeth of the principal cutting edge are stout and seem unusually short, the spine row arising just proximally, and at the outer edge of this there are two minute spines, differing from all the remainder and highly suggestive of a reduced lacinia, such as is seen in *Phreatoicoides* or *Uramphisopus*; several plumed setae spring from the base of this spine row and the molar is curiously produced mesially. The palp rises from a short, broad elevation which bears two setae; its first joint is as wide as long and has an apical tuft of setae; the second joint, nearly three times as long, has a sub-terminal rank of five long and stiff, doubly-pectinate setae, arranged almost transversely, proximal to which are a few variable, simple setae; the third joint, almost equalling the second in length, has a long series of setae for the most part arranged in three rows, one of these rows including a set of seven stout spine-setae, denticulate on one edge and finely pectinate on the other; apically, and seeming to rise at a different level, are three long, finely feathered setae; the whole face of this joint is covered with tufts of fine setules.

The *lower lip* (fig. 61, *7*) shows little indication of division into inner and outer lobes; its mesial fringe of setae is very dense and seems to include several setospines, including one, unusually stout, which is borne apically.

The *maxillula* (fig. 61, *8*) calls for little comment; the outer endite has apically about fifteen spine-teeth, one, at least, of which is a characteristic setospine, and this seems to spring a little sub-apically; there are the usual two plumed setae. On the inner endite are only four setospines, but one of the two spines normally simple in this family is here feebly ciliate.

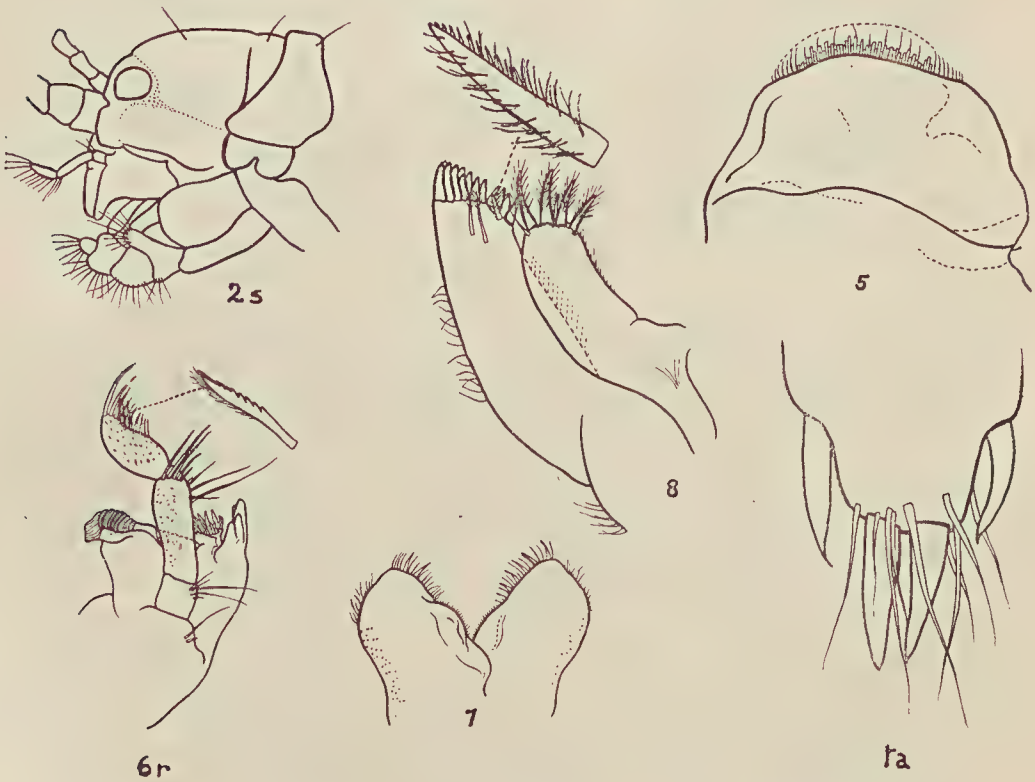


FIG. 61.—*Colacanthotelson rugosus*, sp. n.

The *maxilla* (fig. 61A, *9*), too, seems normal, except perhaps that the endites are shorter, relatively.

The *maxilliped* (fig. 61A, *10*) bears twelve brush setae on the dorso-mesial edge of the endite, the setae at the proximal end of that structure being long and some, at least, pectinate; the epipodite has a half-circlet of setules fringing its outer (upper) border.

The *gnathopod* (fig. 61A, *11*) differs from that of *M. australis* in several details; the basis is devoid of setae and there are very few on the ischium; the merus seems rather unusually produced; the propod is not greatly enlarged and

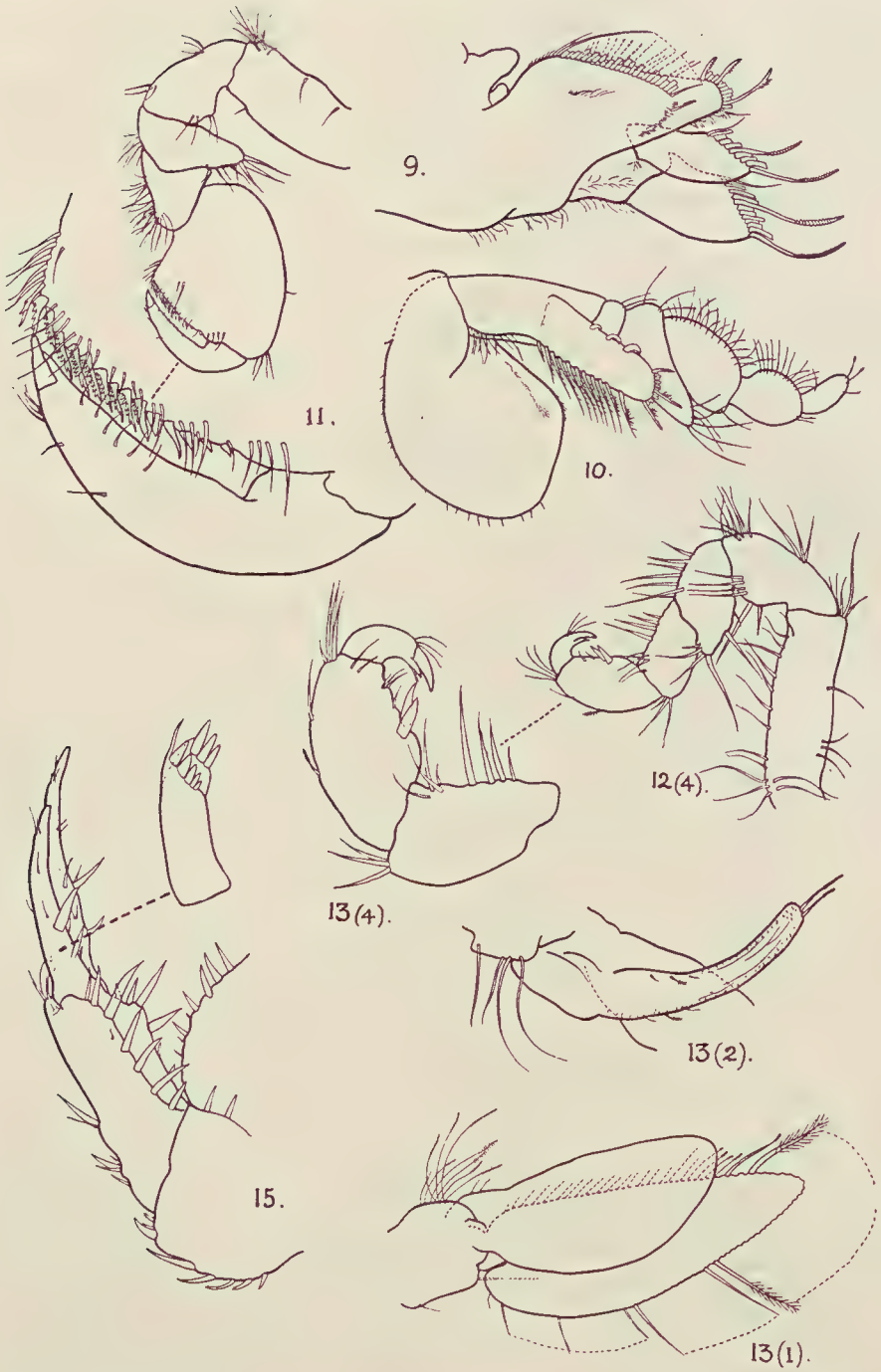


FIG. 61A.—*Colacanthotelson rugosus*, sp. n.

its whole distal (palmar) end is fringed with long, slender setae; about ten denticulated spines, so usual on the palm, are present, but there is, also, a series of simple spine-teeth which makes this appendage quite distinctive.

The *fourth peraeopod* (fig. 61A, *12(4)*), in its armature of setae and in the proportions of basis and ischium, comes near to that of *M. decipiens*, from which however, it differs in the shape of the propod. The hinder peraeopods are slender and less setose than those of *M. australis*, but they differ most markedly in the absence of any expansion of the basis, in this most nearly resembling *tasmaniae*.

The *pleopods* generally seem normal, but the endopodites of the first and second lack the terminal emargination seen in *M. australis*, *C. chiltoni*, etc. In the first pleopod (fig. 61A, *13(1)*) the endopodite seems unusually widely based; the exopodite is, as usual, fringed with long setae which in the distal third are mostly plumose; an unusual feature, however, is the presence (between the bases of the longer setae) of short, stiff setae, which are reminiscent of the short spines occurring in this position in the corresponding appendage in *tasmaniae*.

Upon the second pleopod, the penial stylet differs from *M. australis* in that there are (as in *M. tasmaniae*) but two terminal setae which are doubly pectinate; both free inrolled borders of the stylet bear short, stiff setae, some of which are pectinate.

The *uropods* (fig. 61A, *15*) are slender and rather long, projecting behind the telsonic apex; the inner upper edge of the peduncle is well raised distally and bears one stout and two lesser spines; the outer edge has a series of about six spines, all moderately stout; along the ventral edge are two tufts of setae, each with an accompanying spine. At the lower distal end of the peduncle are one stout, but quite short, digitate spine and two slender, simple spines.

The inner ramus is as long as the peduncle and bears one or more spines at nodes about one-third and two-thirds of its length. The outer ramus is similar, but slightly shorter, with a single spine at mid-length and a second more proximally.

A second specimen shows some scattered setae as well as spines upon these rami.

Size. About 13 mm.

Occurrence. Thomson's Flat, Mt. Kosciusko, 5700 ft. (collected by C. Hedley, 15/2/01) and (?) at Piper's Creek.

This material from both sources had been preserved in alcohol for many years, and had, doubtless, undergone some bleaching. The specimens were brown in colour and noticeably different from the *australis* with which they were associated; the rugosity of the body, too, and the telsonic projection, though not so greatly longer than that of *australis*, were both distinctive. In the case of the first example observed, it seemed possible that it was a Tasmanian specimen which had accidently become included, but detailed comparison showed it to be assignable to no known Tasmanian species.

It is of interest that Chilton had noted (1891, p. 151) that specimens of *australis* had the body 'wrinkled into irregular depressions', this suggesting that some examples of this species were probably present in the first batch of specimens[1] examined by him, for, as noted below (p. 145), the body of *M. australis* (Chilton) cannot be described as wrinkled.

---

(1) Taken at 'Piper's Creek, Mt. Kosciusko, 6000 ft.'.

The association, on or near the summit of this isolated peak, of two distinct species which seem to find their nearest kinship in the similarly isolated Tasmanian Plateau, is of considerable interest. It is to be noted that Phreatoicids, with the possible exception of subterranean forms, have practically disappeared from the lower levels of the mainland portion of the Bassian region. Such surface-water survivors as there are occur only on isolated mountain tops, whereas, in Tasmania, forms akin to *australis* are found practically at sea-level.

Sub-family VIII. PARAPHREATOICINAE

Body slightly wrinkled or smooth, sparsely setose, never spinose; eyes rarely prominent, generally small, approaching obsolescence or entirely wanting; peraeon sub-cylindrical, segments usually not deeper than long, without transverse bands of setae; the incomplete suture between sixth pleon segment and telson marked by a line of stiff setae; tailpiece sharply upturned, short, and slightly tapering or truncated.

Antennule usually short, club-shaped. Maxillula, with four setospines on inner endite; coxae of sixth and seventh peraeopods little produced posteriorly, bases of hinder peraeopods expanded; spine beneath insertion of the rami of the peduncle toothed.

Three genera, *Paraphreatoicus*, *Colubotelson*, and *Metaphreatoicus*.

This sub-family is the largest of any of the Phreatoicidae, containing, as it does, nearly one-third of the known forms.

Paraphreatoicus relictus is of particular interest, for it retains the primitively fringed condition of the endopodite of the first pleopod. A comparable condition is seen in one New Zealand genus, while in the South African *Mesamphisopus* all of the five endopodites bear a fringe, variably incomplete, of such plumed setae, and in some restricted to the apex of the lamella. The only Tasmanian species hitherto known, which has setae on this lamella is *Hypsimetopus intrusor*, and in this case the fringe is very sparse, a reduction related doubtless to the generally degenerate condition of the pleopods following the adaptation to life in underground waters.

The condition of the tailpiece, and particularly of the telsonic process, suggests that the members of this sub-family have been derived from a Mescanthotelsonine ancestor, which must, however, have been more primitive than any extant form, since none of these retain the setal fringe upon both lamellae of the first pleopod.

The shape of the telsonic process in *P. relictus* suggests that in this process of reduction, it has passed through a phase still retained in *Onchotelson brevicaudatus*. To this latter species, *P. relictus* shows a likeness, also, in the marked setosity of both lamellar faces of the exopodite of the first pleopod, as well as in the strongly armed condition of the free border of the sixth pleon pleura.

From a condition like that of *P. relictus*, that of members of the genus *Colubotelson* is readily derivable by loss of the setose condition of the endopodites of the first pair of pleopods and progressive modification of the tailpiece.

Paraphreatoicus, gen. n.

Telsonic process sharply upturned and abruptly truncated; armed terminally with four stout spines. The endopodite of the first pleopod almost completely fringed with setae, some of which are plumose.

Genotype. *Paraphreatoicus relictus*, sp. n.

Paraphreatoicus relictus, sp. n.

(Fig. 62)

A species of medium size, in general appearance much like *australis*, but differing from all known Australian species in that the first pleopod retains the setose condition of the endopodite.

Body smooth, with few setae. *Head* shallow in front; eyes small; sub-ocular incisure shallow; cervical groove incomplete; post-mandibular region moderately developed with small posterior process.

Peraeon. First segment short, widening ventrally; second, third, and fourth sub-equal in length, but increasing in depth; fifth, sixth, and seventh decreasing progressively in length; seventh about one-and-a-half as long as the first.

In the *pleon*, the first and second segments are short and sub-equal, third and fourth much longer, fifth as long as the second and third combined.

Tailpiece barely as long as the fifth segment; telsonic apex upturned and very short, behind a broad, shallow depression.

The *antennule* (fig. 62, *4*) is about as long as the peduncle of the antenna; its flagellum is six-jointed, the penultimate being long. The *antenna* has short first and second joints, third and fourth sub-equal, fifth more slender and less than the combined length of the third and fourth joints; in the flagellum there are sixteen joints, the more distal being long and slender.

The *mandible* (fig. 62, *6*) has a stout palp, the third joint little shorter than the second, the terminal tuft of pectinate setae in two or three rows, while the setae forming a row half-circling the apex of the second joint are long and pectinate. The cutting edge with four stout teeth; the molar produced.

The *maxillula* is normal, the outer endite with ten spines and one setospine, with the usual two plumose setae on the posterior face.

The *maxilla* (fig. 62, *9*) shows the inner endite widened basally, the filtratory setae passing onto its anterior face and ending distally in a shorter seta with a short, double pectination apically; the anterior spine is short, a little proximal to the end of the row of filtratory setae and is pectinate on one side; the filtratory setae are backed by about nine biting setae, rather widely spaced.

On the *maxilliped* (fig. 62, *10*) the inner border of ischium and merus is slightly produced mesially, the epipodite narrow, its lateral border with a fringe of setae; the brush setae on the upper border of the endite about fifteen in number; the dactyl narrow, lanceolate.

The *gnathopod* (fig. 62, *11*) of the male is short, rather robust, its basis slightly widened, little longer than the ischium, the propod with anterior border convex, palm oblique, nearly straight, armed with about fifteen spine-teeth, the eleven more posterior being denticulate, while the four nearer the dactyl are reduced progressively in size and are simple; the free posterior border of the joint is nearly two-thirds of the length of the palm. The fourth *peraeopod* (fig. 62, *12(4)*) shows some modification, the slightly concave palm occupying three-fourths of the posterior border of the propod. The peraeopods of the hinder group are elongate, the basis slightly expanded; the ischium is long, the propod slightly longer and slender. In the seventh (fig. 62, *12(7)*) the dactyl is three-fourths of the length of the propod. As a whole the limb is setose, approaching spinose.

It is in the first *pleopod* (fig. 62, *13(1)*), however, that this species is distinctive. The appendage is well developed and slender, but the sympodite is wide, its mesial border with a number of pectinate entangling setae, its outer border produced and fringed with long setae, some of which are feebly ciliated. The

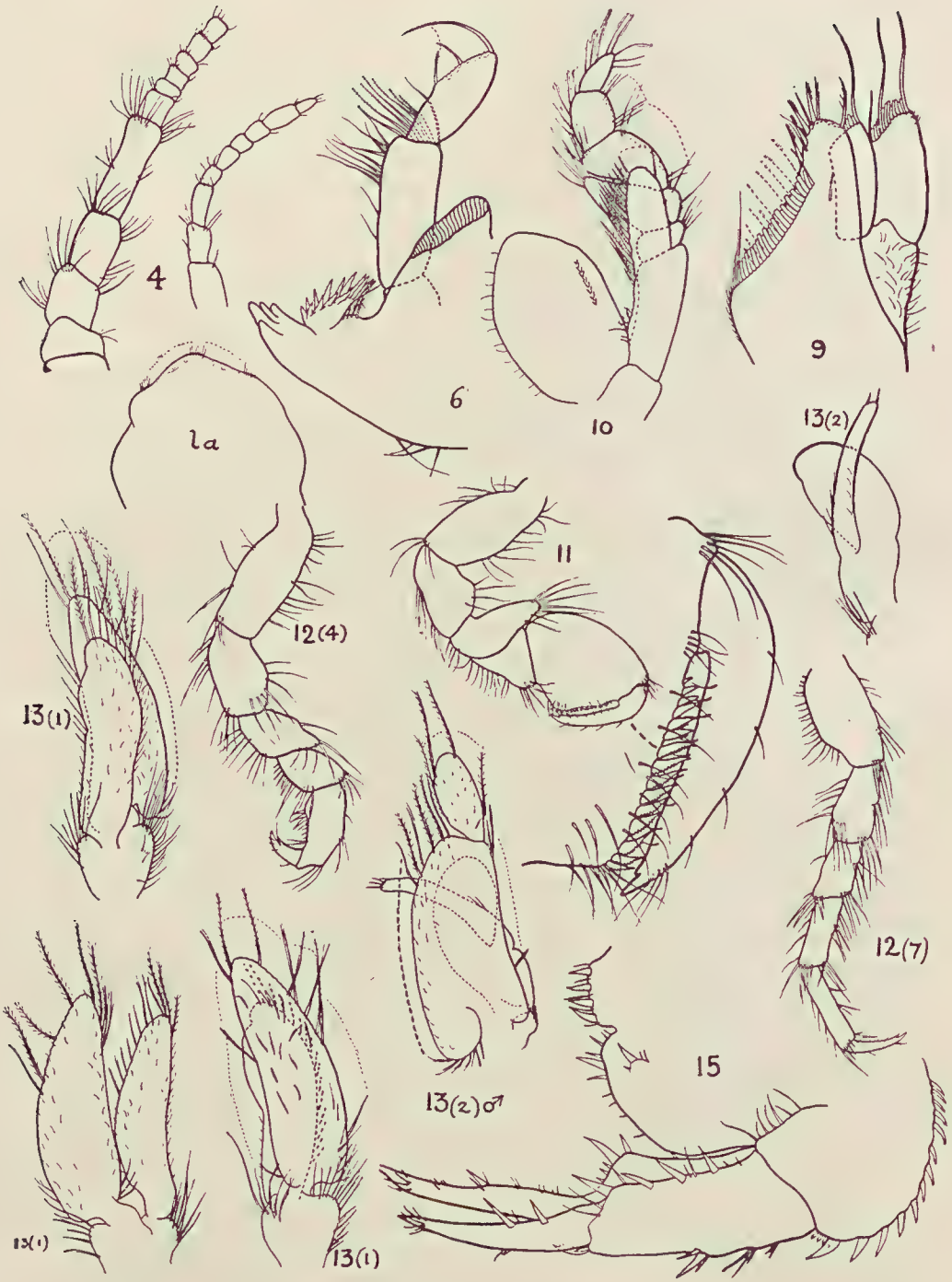


FIG. 62.—*Paraphreatoicus relictus*, sp. n.

exopodite is long-lanceolate in shape, with apex rounded and bearing a few plumose setae, extending for a short distance laterally; the rest of the lateral border has a sparse fringe of long, flexible, simple setae. On the mesial border of the exopodite the terminal third bears pectinate setae; the rest are long, simple setae. The whole anterior face and a wide outer margin of the posterior face bear numerous stout, simple setae. The endopodite is narrow basally, then widens, and finally narrows near the apex; it is fringed along most of its inner border with setae, short proximally, longer and some pectinate distally, with a few plumose apically, and laterally a fringe of longish, simple setae. The posterior face of the endopodite is remarkable for a sprinkling of short setae like those on both faces of the exopodite. In a second specimen there is some variation in the setae, although the general condition is much the same.

On the second pleopod of the male (fig. 62, *13(2)*) the entangling lobe bears four stout setae, the exopodite with relatively few plumose setae near the end of the proximal joint and around the distal lobe; the greater part of the lateral and distal borders being fringed with long, simple setae; the anterior surface of both lobes carrying scattered, short setae. The endopodite, nearly as long as the basal lobe of the exopodite, is subdivided indistinctly at the level of the base of the penial stylet; this stylet is long and cylindrical, armed mesially with four or five setae, laterally with rather fewer and terminally with four stiff setae (in one specimen, two only).

The *tailpiece* is figured with the telsonic apex displaced to appear in the side view. It is short, much wider than long, and armed only with four stout spines; the telsonic pleura are little produced and fringed with a spine and several spinules or setae, with one stout, sub-marginal spine; the suture with the sixth pleon pleuron is marked by a short ridge bearing six or seven setae. The antero-ventral border of the pleuron bears an unusually extensive fringe of spinules, twelve or thirteen, apically denticulate; the hindmost, which may be simple, is flanked by four furcate spinules.

The *uropod* is long, extending well behind the telson; the inner, upper border of the peduncle is well raised and bears one particularly stout spine apically. The two rami are long, the inner a little the longer, sub-equal to the peduncle; the outer ramus shows the more primitive condition with two spines—one at mid-length and one more proximally; in some specimens the two are quite close.

Beneath the insertion of the rami are two spines of unequal size, both toothed apically.

Size. About 12 mm.

Colour. In life, dark grey, some nearly black, abundantly marbled on the sides with chestnut-brown; after long preservation in spirit they fade to a pale straw colour.

Occurrence. Under stones and amongst roots of water plants in Stringy-bark Creek at Woodbury, Tasmania. It occurs, but less plentifully, in several adjacent creeks, from St. Peter's Pass and down through Antill Ponds.

In the retention of a well-developed fringe of setae, the condition of the endopodite of the first pleopod approaches that seen in the blind New Zealand surface forms; actually, the plumose setae are not very numerous, but other setae make the fringe almost complete. The endopodite is smaller than the exopodite, in this resembling the South African species of *Mesamphisopus*, but in that genus this setose condition of the endopodite is not restricted, as here, to the first pleopod.

It is undoubtedly the retention of a primitive condition which has disappeared in all other of the known species of this sub-family. On the telsonic process four

spines constitute the sole armature, and it seems probable that this number, found in so many species, is nearer to the earlier condition, and that the occurrence of three pairs of spines in *Metaphreatoicus* is due to the development of an additional pair of spines, stages of which are seen, perhaps, in *M. magistri* and *M. affinis*. The extensive fringe of spines upon the sixth pleon pleuron is paralleled in *O. brevicaudatus*, *N. littoralis*, and *M. australis*, and while it, too, may represent an early condition in the Phreatoicidae, it should be noted that other primitive species, such as *M. tasmaniae*, *P. typicus*, and *C. mixtus*, show few spines on this border.

Colubotelson, gen. n.

Telsonic process sharply upturned, very short, and bearing but two pairs of stout, apical spines; endopodite of first pleopod lacking any setal fringe.

Genotype. *Colubotelson joyneri*.

Colubotelson joyneri (Nicholls)

(Fig. 63)

Nicholls, 1926, p. 183, pl. 25, 26, and 29 *(Phreatoicus joyneri)*.
Sayce, 1904, p. 151 *(Phreatoicus australis)*.

This species having been described in considerable detail, there will be little need to do more than consider those characters in which it differs from *M. australis* (Chilton) or other alpine species.

The *body* (fig. 6, *1*) is smooth and only sparsely setose; the length of pleon to that of cephalon and peraeon combined is as 62 : 100. The head seems relatively short and deep. The eye has undergone greater reduction, there being only twelve to fourteen ommatidia. The *antennule* is short; the *antenna* is nearly half the length of the body; the fifth joint of the peduncle is rather long; the flagellum of about twenty joints, is little more than twice the length of the peduncle.

The first *peraeon* segment is expanded noticeably ventrally.

The *gnathopod* of the male shows the propod very robust; upon the palm is a raised convex edge bearing about a dozen spines, of which some nearer the dactyl are tooth-like; traced posteriorly they become elongate and four are denticulate; at the limit of the palm they are continued posteriorly in a close-set rank of four or five slender spines; the hinder border of the propod is straight, about two-thirds of the length of the palm.

All four of the peraeopods of the anterior group seem to possess some degree of prehensility, the propod having a rudimentary palm and a couple of stout spines. In the male the fourth peraeopod shows this condition quite well developed. The bases of the hinder peraeopods are rather more widely expanded. The male appendage widens apically and is armed with three stiff setae; there is, also, a row of setae along its length.

The *pleon* is shorter, but its maximum depth is relatively rather greater than in *australis*. Of the pleopods, it may be noted that the endopodite of the first is produced into a small proximal lobe; the second in the male shows the penial stylet long and slender, armed terminally with four or five stiff spine-setae. The entangling setae on the sympodite are long, stout, and doubly pectinate.

It is in the *tailpiece*, however (fig. 63, *3*), that this species differs most evidently from *australis*. As seen in the *habitus* figure (Nicholls, 1926, pl. 25, fig. 1), the tailpiece is nearly as long as the combined length of fourth and fifth

pleon segments. Seen in profile the dorsal surface appears not markedly convex and the tip-tilted telsonic apex projects little, if at all, behind the telsonic pleura. The actual apex bears four equidistant spines, interspersed with which are a dozen to fifteen short, flexible setae. The antero-ventral margin of the tailpiece (the free border of the sixth pleon segment) is armed with spines and spinules. These are usually eight in number; the six more anteriorly situated are denticulate apically and, at first quite short, increase progressively in size as they are traced posteriorly; they are followed by two much stouter, simple spines; flanking the last is a short series of three or four small spinules, which may be simple or digitate.

The telsonic pleura which flare out behind and below the apex are unusual, for, except for one posteriorly placed marginal spine and a small sub-marginal, this border is bare of setae. The junction of this telsonic pleuron with that of the preceding segment is marked by a slight ridge situated just above the insertion of the uropod; it is shorter and less distinct than in *australis* and is armed with a few short setae, irregularly spaced, differing markedly from the comb-like row seen in *australis*.

The *uropod* is stout and of moderate length; upon the peduncle, the inner border is raised terminally and armed with the usual two stout spines with one or more supporting spinules; the outer border is armed along its length with a series of six or seven stout spines. The ventral border bears, in its anterior half, three tufts of setae, each usually with one stout spine. The end of the peduncle, beneath the insertion of the rami, bears one unusually large denticulate spine with a similar, but smaller, spine mesially and a slender simple spine laterally.

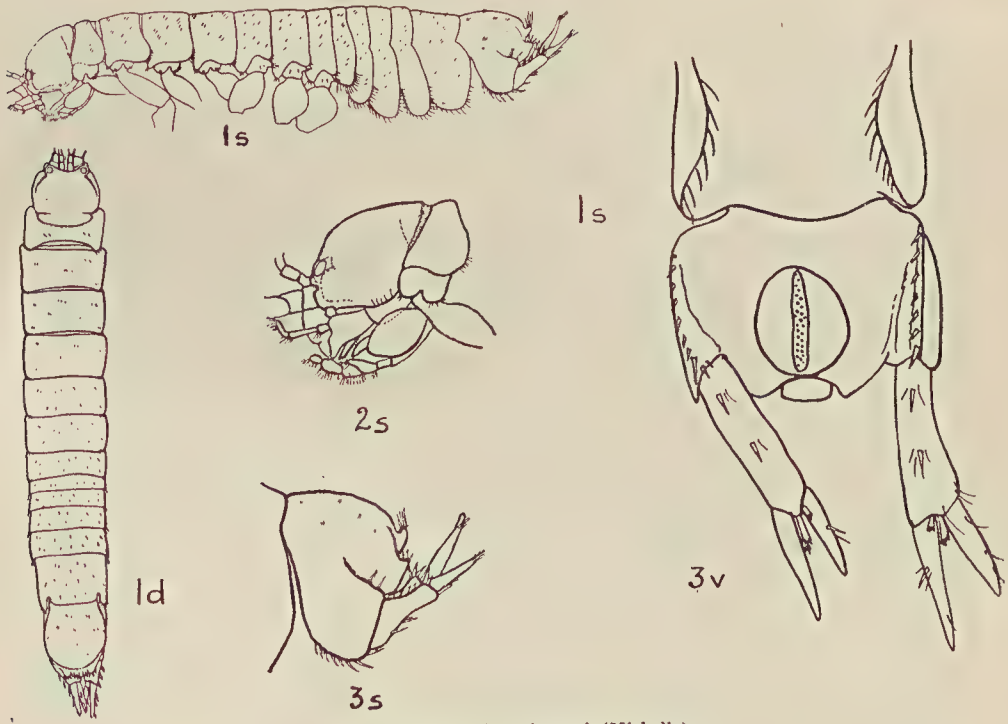


FIG. 63.—*Colubotelson joyneri* (Nicholls).

The inner and longer ramus is rather shorter than the peduncle, the outer ramus only about two-thirds of that, or about four times the length of the denticulated spine. The rami are practically unarmed; each bears two small tufts of setae and, rarely, there may be a single slender spine associated with the more proximal tuft.

Size. The largest male obtained measured 14 mm.

Colour. Varying with habitat from very dark to pale brown.

Occurrence. This species has been taken twice by the writer (in 1925 and 1934) in several localities on and near the summit of Mt. Buffalo, Victoria. Although prolonged search was made, it was not found at or near the base of the mountain. It occurs in black ooze in shallow ditches and puddles, beneath sphagnum in several boggy areas and, in one or two cases, in fairly fast-flowing creeks. Specimens were also taken sparingly along the banks of Lake Catani, but not in the reservoir. It would seem that it requires a sheltered situation, and the reduced condition of the eye supports this view, but it may be that food is not so readily available on the gravelly bottom of the lake.[1]

Recently, Phreatoicids from the Great Lake, Tasmania (presumably a mixed collection), have been introduced into Lake Catani[2] as a source of trout food, and it will be of interest to discover whether conditions in the lake are unfavourable only to the local species, or unsuitable for Phreatoicids generally. It is, of course, possible that the scarcity of the animal in the lake was due to the presence of trout!

Colubotelson joyneri searlei, sub-sp. n.

(Figs 64 and 80, *a*)

In general, agreeing quite closely with the Mt. Buffalo species, but differing in the following details:

The eye is slightly less reduced, having about twenty ommatidia; but the antennule is shorter and retains only four joints in the flagellum. The gnathopod is less robust, and upon its palm about six of the more posterior spines are stout and denticulate, while the remaining six, which stretch to the base of the dactyl, become small, conical, and simple (fig. 64, *11h*). The hinder border of the propod is short, about one-third of the length of the palm; the fourth peraeopod of the male (fig. 64, *12(4)*), which is sexually modified, is robust, propod stout with short concave palm; the ischium on this appendage is little more than half the length of the basis, the latter bearing only three or four setae. The seventh peraeopod (fig. 64, *12(7)*), although bearing a distinct plate-like expansion posteriorly, is relatively slightly longer and narrower than in *joyneri*; the male appendage short and unarmed.

The specimens had been collected and allowed to dry, so that the pleopods were in a poor state of preservation. The tailpiece showed a telsonic apex very closely like that of *joyneri*, but in dorsal view this is found to project directly from the anterior part of the piece, whereas, in *joyneri*, it is separated by a shallow gap from the flanking telsonic pleura (1926, pl. 29, fig. 40). The latter differ in armature scarcely at all from *joyneri*, and the same is true for the sixth pleon pleura, but the suture, above the insertion of the uropod separating these two pleura, is marked by a line of eight or nine slender setae.

---

(1) Among Chilton's notes, there was found a reference to the taking of '*P. australis*'. (Sayce, Victorian Naturalist, v. 20, March, 1904) at the 'Haunted Gorge' on the summit of Mt. Buffalo.

(2) *fide* J. W. Evans, *in litt.* 7/4/41.

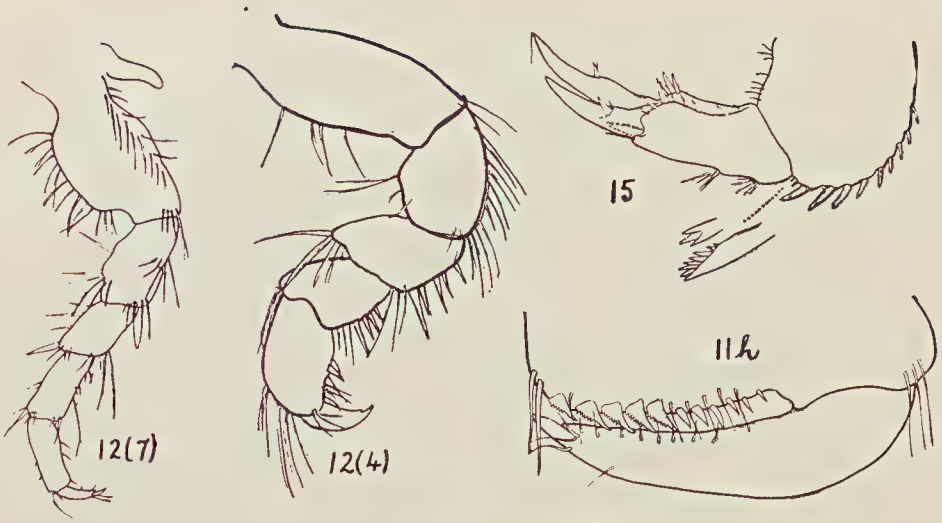


FIG. 64.—*Colubotelson joyneri searlei*, sub-sp. n.

The uropods, too, are closely alike (fig. 64, *15*), but both rami bear a particularly stout spine at about their mid-length, whereas, in *joyneri*, the sole armature frequently consists of a few setae.

Size. ♂ 14-15 mm.; ♀ 11 mm.

Colour. Dark brown with lighter marbling.

Occurrence. Collected on Mt. Baw Baw by Mr. Jas. Searle (26/1/14).

Colubotelson thomsoni, sp. n.

(Figs 65 and 80, *d*)

Thomson, 1893, p. 76 *(Phreatoicus australis)*.
Thomson, 1894, p. 349 *(Phreatoicus tasmaniae* juv.*)*.
Smith, G. M., 1909, p. 72, pl. 12, fig. 4 (*Phreatoicus australis* part).
Barnard, K., 1914, pp. 233 and 239; 1927, p. 160 *(Phreatoicus australis)*.

This species, which was apparently first recorded by G. M. Thomson in 1892, closely resembles *C. joyneri*, but in the condition of the tailpiece seems intermediate between that species and *M. magistri*.

The eyes are small, not prominent, and do not appear in the profile of the head, the front rising even more steeply than in *magistri*; the post-mandibular region is small; the cervical groove is relatively well developed.

In the peraeopods it is to be noted that the antero-posterior axis of the basis is disposed nearly parallel to the long axis of the body, so that the anterior border of the limb is scarcely visible. Only in an occasional specimen does there appear that partial torsion of the limb which is normal for many species.

In the pleon the ventral and hinder margins of the first to fifth segments are fringed with long setae, interspersed in a dense fringe of short setules. The tailpiece shows the telsonic projection more tip-tilted, and distinctly shorter, so that the preceding dorsal concavity is relatively slight. The actual hinder margin is smoothly rounded, armed with four short spinules and a few long setae; on either side near its base are a couple of longer, stiff spine-setae which represent, possibly in a rudimentary condition, the outermost pair of spines of *Metaphreatoicus* spp.

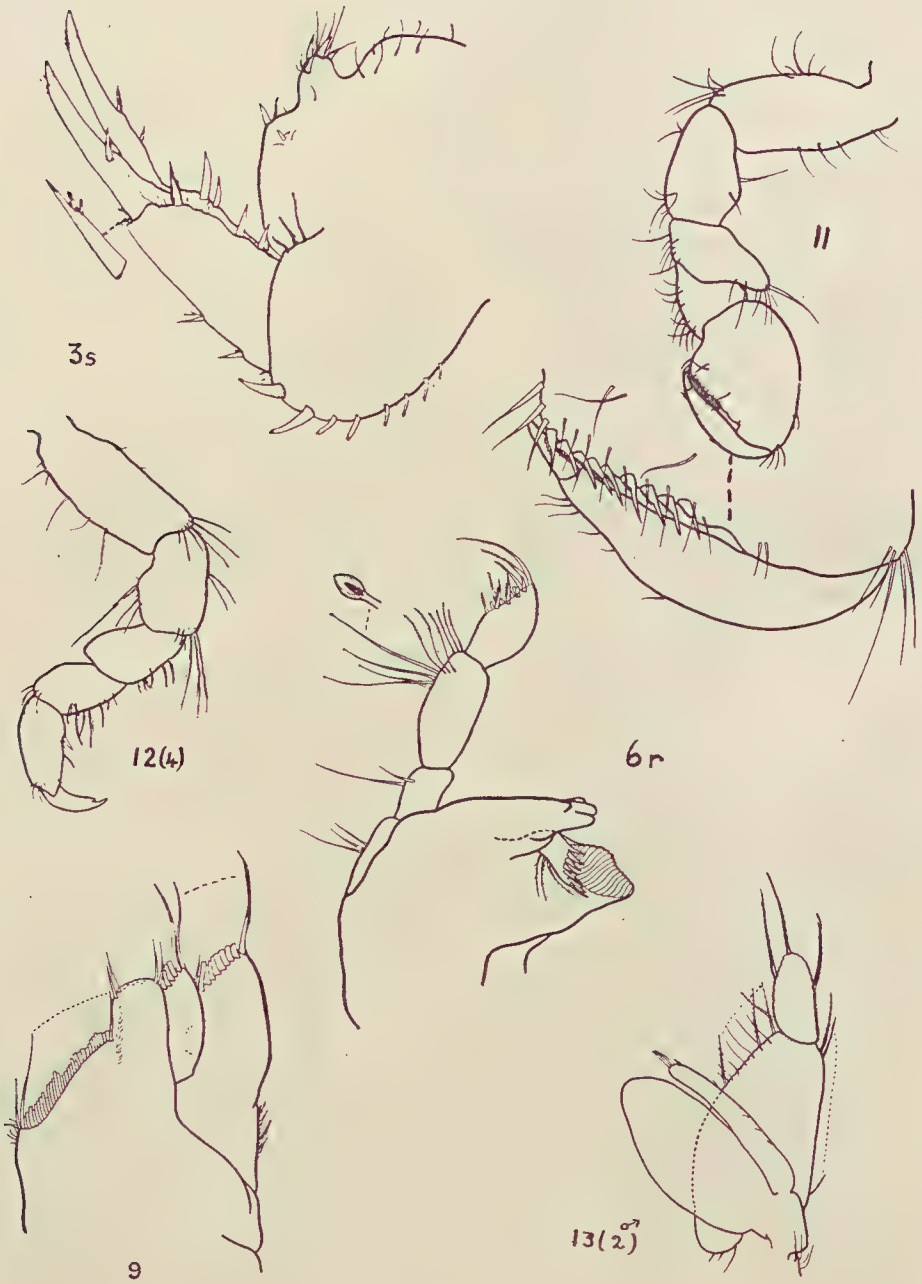


FIG. 65.—*Colubotelson thomsoni*, sp. n.

The telsonic pleura are rounded and project very little, if at all, behind the telsonic apex; in their upper part, these pleura bear two marginal spines and, below, two setae; anteriorly is the usual sub-marginal spine. The pleura of the sixth pleon segment are broad, armed antero-ventrally and ventrally with six or seven toothed spines and one particularly stout, simple spine (which may, variably, bear traces of apical denticles); flanking this last spine may be one or two spinules, which may be simple or furcate. The suture between sixth pleon and telsonic pleura is indicated by a short ridge with two, three, or four long, stiff setae.

Appendages. The *antennule* is short, with but five joints in the flagellum. The *antenna* seems less robust than that of *australis*; it has fewer (not exceeding twenty-one) flagellar joints, but these are fairly long, so that the appendage as a whole is relatively longer. The *labrum* is asymmetrical; the incisures on either side for the reception of the mandibular palps are unevenly developed. On the mandible (fig. 65, *6*) there are two or three plumed setae just proximal to the spine row; the third joint of the palp is stout, the setae being disposed in two or three rows. On the second joint, which in length does not greatly exceed the third, there is an apical tuft of pectinate setae, while upon its outer margin are longer, simple setae, some with small spatulate or knob-like apices.

The *maxillula* seems normal, but in the *maxilla* (fig. 65, *9*) the inner endite seems of quite unusual width, the row of filtratory setae disposed in a line at a very wide angle to the apical lobe. It is backed by about sixteen biting setae. The usual spine on the anterior face of the endite was not observed; all three endites are short and wide.

The *gnathopod* (fig. 65, *11*) of the male is much less robust than that of *joyneri*; the palm, which is very obliquely set, is nearly straight and bears nine denticulate spines; upon the dactyl the unguis is simple, the secondary unguis wanting.

In the fourth *peraeopod* of the male (fig. 65, *12(4)*) the propod is scarcely widened, the dactyl very slightly curved. Upon the basis setae occur more sparsely even than in *joyneri*. The basis of the hinder peraeopods is rather less expanded than in *australis*.

The first *pleopod* differs from that of *australis* in a couple of details: the sympodite is practically bare of setae and the exopodite has, in addition to its apical series of plumose setae, a subsidiary fringe of simple setae, projecting at a different angle; the second pleopod in the male shows the penial stylet with a few marginal setae mesially, and three stiffer spine-setae apically; in the exopodite, the mesial aspect of the distal lobe bears a fringe of short setae (fig. 65, *13(2)*).

The uropod (fig. 65, *3s.*) has an unusually short peduncle, which in length is sub-equal to, or even shorter than, the inner ramus; the terminal spine on the peduncle is somewhat variable, being in one case a slender tridentate spine; usually there are either one or two more typical toothed spines, relatively short and stout. Each ramus bears several setae and one slender spine.

Size. About 12·5 mm.

Colour. Closely resembles *australis*.

Occurrence. Found abundantly on the summit of Mt. Wellington, on wet slabs of rock, covered by moss or liverwort; also in puddles on the 'plains', and in runnels upon the higher slopes of the mountain. It may be found in the Ridgeway reservoir and, in the overflow from that, at a level of a few hundred feet only above sea-level, and is thus the only species known to have a considerable vertical range.

Colubotelson evansi, sp. n.

(Figs 66 and 80, *e*)

A species of small size with affinities to *C. joyneri*.

The body is somewhat slender, with a very sparse covering of short, fine setae; the head is as long as the combined length of the first two peraeon segments, with moderately large eyes (about 32 ommatidia); the cervical groove is deep and traceable almost to the ventro-lateral border of the head. In the peraeon the first segment is short and widens below, but instead of embracing the head seems to project backward postero-ventrally over the second segment. Third and fourth segments sub-equal and longest, fifth as long as second, seventh distinctly longer than first; the segments are relatively deep; from the third backward the depth is greater than the length. In the pleon the first four segments lengthen and deepen progressively; the fifth is long, as long as the tailpiece. The tailpiece, as viewed from the side, is convex and produced into a telsonic projection which is short and much less tip-tilted than is the rule in species of this genus, so that there is but a shallow, rounded concavity preceding the apex. The projection, too, examined from above (fig. 80, *e*), is unusually long, its shape semi-circular, and its four spines evenly spaced around its hinder curvature; completing the terminal armature are four longish setae. Below, the telsonic pleuron, which projects little, slopes away smoothly, the border of the pleuron bearing two spines and two or three spinules in a little dorso-posterior group; sub-marginally is a single, stout spine. Ventrally to the group of spinules the border is fringed with fine setules. From immediately above the insertion of the uropod there is a slight ridge, armed with three of four fine setae, marking the feeble boundary between the telsonic and the sixth pleon pleuron. The antero-ventral border of the latter bears a fringe of six or seven curved spinules and spines toothed apically and one much stouter spine, hindmost in position; flanking this latter are, variably, one or two furcate spinelets.

Appendages. The *antennule* is as long as the peduncle of the antenna, although the flagellum has but five joints; the *antenna* is short; the peduncle has the third and fourth joints sub-equal, the fifth barely one-third longer than the fourth; its flagellum has only about fourteen joints, but the first is long, practically as long as the fourth joint of the peduncle.

The *right mandible* (fig. 66, *6r*) bears four plumose setae proximal to the spine row; both second and third joints of the palp are relatively long, the final joint having very few (about eight) slender spines (most being finely denticulated), which seem to be arranged in but a single row.

The *labium* has an inner lobe indicated and at least one setospine seems present apically in the mesial tuft of setae. The *maxillula* appears normal, the setospine on the outer endite being well developed. On the *maxilla* the tuft of pectinate setae arming the apex of the proximal endite are relatively numerous, and both this apical lobe and the outermost endite are comparatively wide; the biting setae on the latter are unusually stout.

Possibly related to the small size of this species, the propod of the *gnathopod* is not particularly robust. The palm is straight and bears a series of the characteristic denticulated spines (fig. 66, *11h*). In this species, there is an interrupted rank of eight, beginning at the extreme border of the palm and passing, near the origin of the dactyl, into lower irregular teeth. The fourth *peraeopod* is obviously prehensile, but the propod is scarcely modified and the dactyl is little curved.

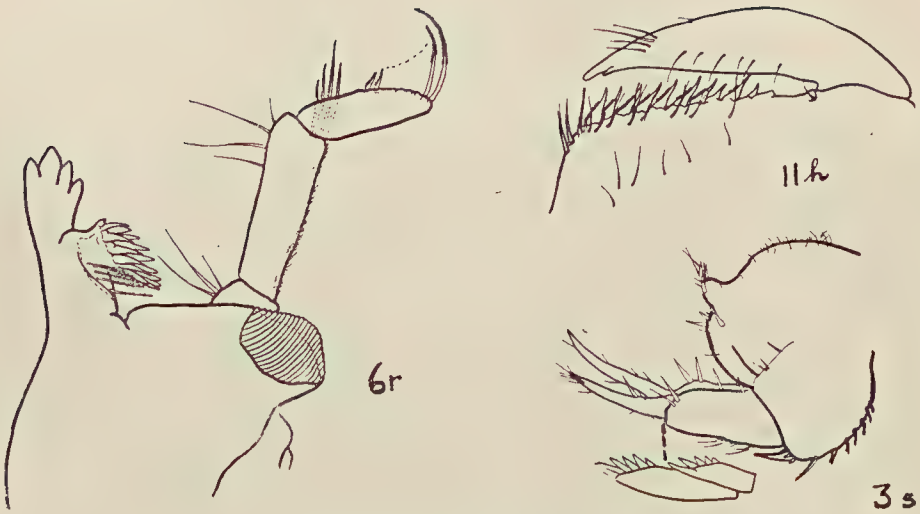


FIG. 66.—*Colubotelson evansi*, sp. n.

The basis in this and the following appendages is not very setose and in the hinder group the expansion of that joint is very slight. In the seventh peraeopod the dactyl is noticeable for its length, which is about three-quarters of that of the propod.

The *pleopods* are not remarkable; the epipodites, however, differ somewhat in shape from *australis* in being a broad oval, rounded apically. In the male the penial stylet is unusual in that it bears but a single apical spine; at its mid-length there is a short mesial seta (as in *Crenoicus* spp.), and at the base of the endopodite are a few stiff setae, not observed in other species.

The pleura are rather sparsely set with long sub-marginal setae, both on the ventral and posterior borders; the actual margin is bordered by a close fringe of short, hair-like setae.

The uropods (fig. 66, *3s*) are of moderate length, the peduncle extending slightly beyond the end of the telson. It is slender, but widens distally, its dorsal surface being distinctly concave, both margins being raised and set with spines; the two rami are slight, the inner sub-equal in length to the peduncle; both bear stiff setae and the outer ramus has one slender spine at its mid-length. There is one stout, strongly-toothed spine beneath the insertion of the rami, and this may be accompanied by a smaller and similar spine or by a slender simple spine.

Size. About 10 mm.

Colour. In life, a dull yellowish-brown, in some cases fading in alcohol to a pale straw colour.

Occurrence. These were taken by the writer (9/2/28) at Waratah, West Tasmania, in ditches in a piece of vacant ground adjoining the hotel.

The species is named in compliment to Dr. J. W. Evans, from whom the writer has received much valuable material.

Colubotelson campestris, sp. n.

(Figs 67 and 80, *b*)

Geoffrey Smith, 1909, p. 72 *(Phreatoicus australis* var.*)*

A smallish species, body length rather more than six times the width, practically smooth and free from setae. The *head* is narrow, as long as the combined length of first and second peraeon segments, shallow in front, becoming much deeper behind; eyes moderately prominent; cervical groove well developed, not complete dorsally. First six *peraeon* segments longer than deep, with the first segment strongly widening ventrally; second to sixth segments sub-equal, the fourth rather the longest; seventh noticeably shorter and much deeper than the sixth. Pleon rather deep, greatest depth sub-equal to length of first four pleon segments, the pleura being much deeper than the related segments. The tailpiece is longer, by the length of the telsonic process, than the fifth pleon segment, moderately convex dorsally, dipping smoothly into a small concavity in front of the very short telsonic projection, which is short, nearly twice as wide as deep, its transverse hinder border scarcely convex, armed with four very stout spines and a few stiff setae; the telsonic pleura project sharply, armed above by one stout marginal and one sub-marginal spine, followed by five or six spinules; the sixth pleon segment having six or seven slender, curved spines, toothed apically, with one much stouter terminal spine and a couple of furcate spinules just anterior to the lower border of the uropod; suture between sixth and telsonic pleura marked by a short, slight ridge, bearing four or five setae.

The *antennule* short, reaching, nevertheless, nearly to the end of the peduncle of the antenna, with eight joints, of which the penultimate is long. The *antenna* has an unusually short second peduncular joint; third sub-equal to first, fourth longer than third, and fifth rather slender and sub-equal to the combined length of the third and fourth; flagellum with sixteen joints, slender, whip-like (fig. 67, *4*).

Upper lip, rather less asymmetrical than in related species; *mandible* unremarkable, excepting for the shortening of the *pars incisiva,* a feature observed in some other species of this genus.

The *maxillula* (fig. 67, *8*) is small, apparently undergoing reduction; upon the outer endite there seem to be but nine or ten spine-teeth and the small setospine is only doubtfully present; there are two feeble plumose setae; the inner endite shows but one (the outer) simple spine; the setospines are four, but the innermost is quite slight. The *maxilliped* (fig. 67, *10*) is remarkable chiefly for the rather unusual size of the epipodite, which is armed along its dorso-lateral border with about half a dozen fine, short setae.

The *gnathopod* is slight, the basis with very few setae, ischium three-fourths the length of the basis, propod sub-triangular, anterior border only gently convex, palm (fig. 67, *11h*) very oblique with ten or eleven slender, denticulate teeth, the free posterior border sinuous, about two-thirds the length of the palm; dactyl moderately long, slender, its palmar border smooth.

The *fourth peraeopod* (fig. 67, *12(4)*) is slight, its more proximal joints agreeing closely with those of the gnathopod, but the propod is slight, a palm is barely indicated and the spines for the reception of the dactyl are short and slender. The hinder peraeopods show a small expansion of the basis, the greatest width of that joint being half its length; setae are few, but on the more distal joint they

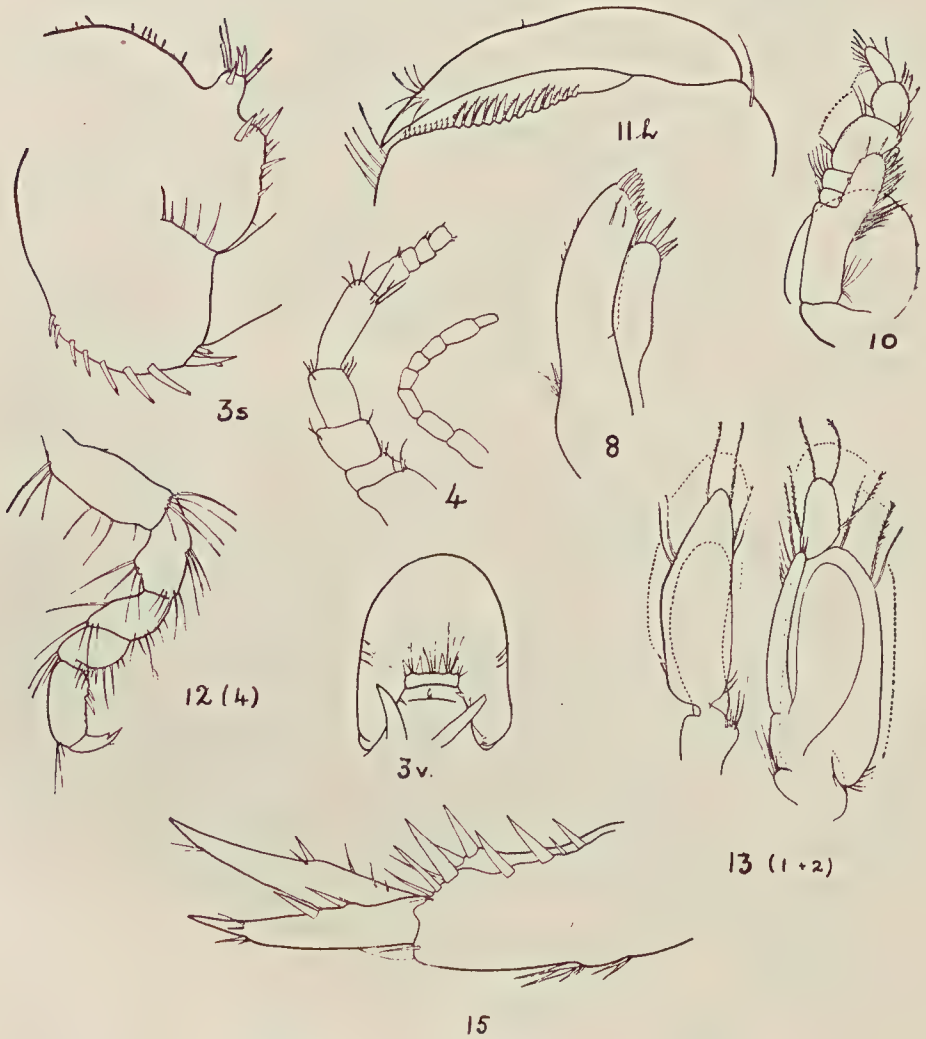


FIG. 67.—*Colubotelson campestris*, sp. n.
The tailpiece *(3v)* is shown in posterior view.

are plentiful and are, in parts, replaced by slender spines. The male appendage is slender and fairly long, its length equalling the maximum width of the basis; it is armed with a terminal seta.

The *pleopods* (fig. 67, *13 (1), (2)*) are unremarkable, although they differ from those of *australis* in the relative proportions of exopodite and endopodite. In the male, the penial stylet upon the second pleopod is much more like that of *magistri* or *chiltoni* than *australis*. In the latter, this stylet is well armed terminally. In this species it is long (as is the related endopodite), bears one longish and one short terminal spine, but otherwise appears unarmed. On the pleura of the pleon segments, the fringe of setae is comparatively feebly developed.

The *uropod* is robust (fig. 67, *15*); its peduncle has a couple of tufts on its ventral margin; dorsally its inner border is armed only apically by two stout spines and smaller flanking spinules; the outer border bears spines along its whole length; both rami are stout, the inner as long as the peduncle and with one stout spine at its mid-length, while the outer ramus retains the more primitive condition with one spine at that point and another more proximally. Beneath the insertion of the rami is one stout, toothed spine, a second similar but smaller, and a slender, simple spine.

Size. 10·5 mm.

Colour. In colour and marking this species retains the condition characteristic of *australis*.

Occurrence. In a paddock at Huntingfield, close to the west shore of the estuary of the Derwent, some miles south of Hobart. This is evidently not quite the same locality as that referred to (1909, p. 72) by Geoffrey Smith (that author speaks of a small stream at sea-level, but it was the only water found by the writer in that vicinity (22/1/1928). It formed a small pond, receiving the drainage from an adjoining cow-barn and stable-yard. From its very evil-smelling mud nearly a hundred specimens were taken, collecting being precarious and intermittent owing to the activity of a bull which was the other occupant of the paddock.

Geoffrey Smith's reference indicates that he regarded specimens from Mt. Wellington, Bruni Island, and Huntingfield as all referable to the same (third) variety of *australis* and, indeed, it might have been expected that at least those from Huntingfield (almost at the foot of Mt. Wellington) would prove to be identical with that *(thomsoni)* from the summit, the more so that the latter occurs at the reservoir only 800 ft. from the sea.[1] That the forms from Bruni Island might prove distinct was more likely, for that island is separated from the mainland by the deep[2] D'Entrecasteaux Channel.

Colubotelson huonensis, sp. n.

(Figs 68 and 80, *c*)

Body sparsely setose, setae being a little more plentiful on the tailpiece; the head almost as long as the combined length of the first two peraeon segments; it is shallow in front, much deeper behind; eye moderately large (about thirty

---

[1] It should be noted, however, that *thomsoni* has elsewhere not been recorded from the slopes of Mt. Wellington. (It does not occur in the New Town Creek, for example, although *Anaspides* is found thriving there at less than 1000 ft. above sea-level.) Its occurrence at the reservoir is probably unnatural.

[2] Information is not available as to the probable antiquity of this channel separating Bruni Island from the adjoining Tasmanian coast. It is, however, quite deep, and lodges those living fossils *Neotrigonia margaretacea*.

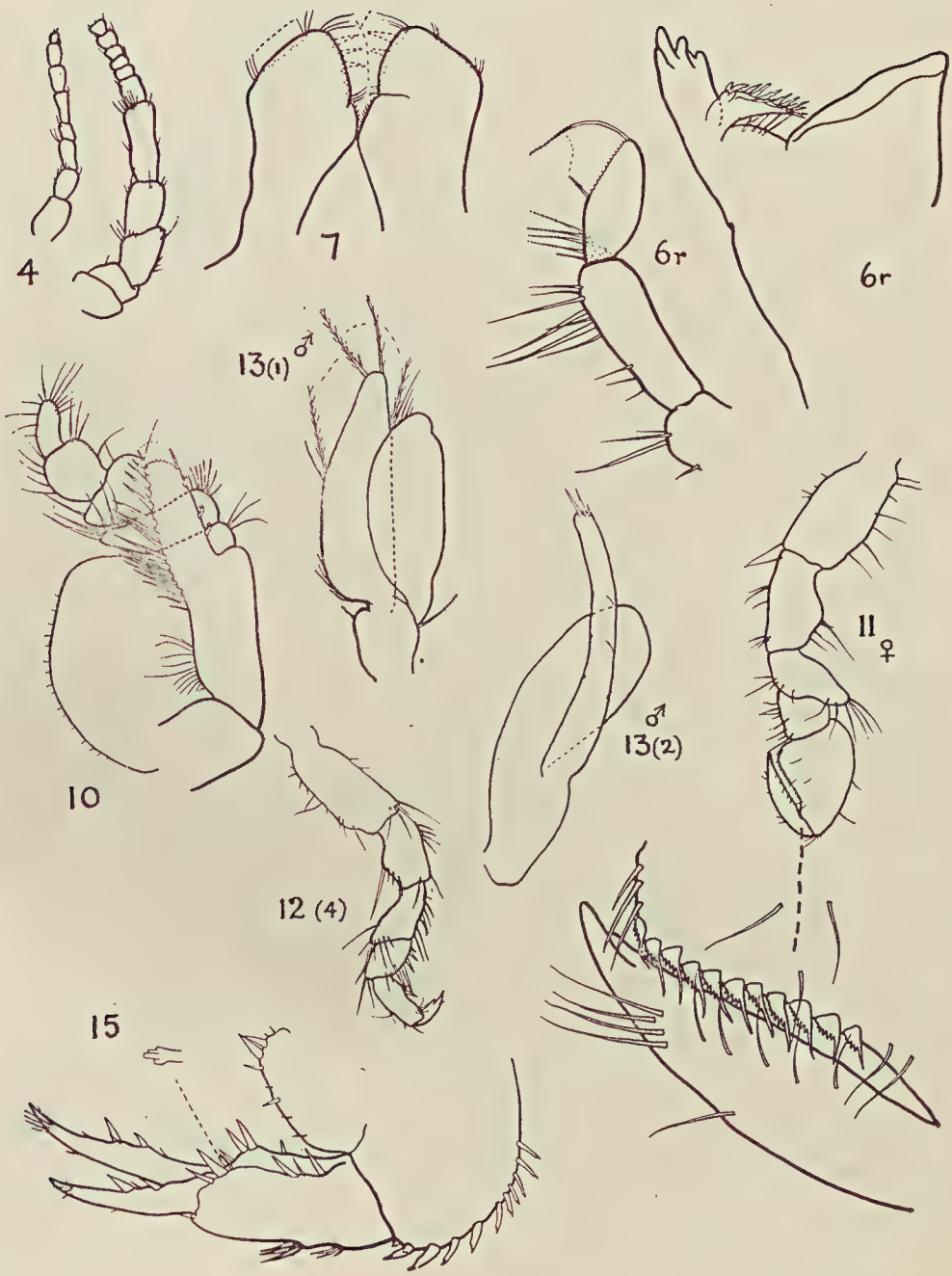


FIG. 68.—*Colubotelson huonensis*, sp. n.

ommatidia) sub-ocular incisure distinct, cervical groove well developed. All the peraeon segments are deep, the first segment short, not greatly widened below, downwardly produced in front of large coxa; third segment longest, fifth and sixth sub-equal, seventh about as long as the first. First four pleon segments increasing progressively in length, the fifth nearly as long as the first three; the tailpiece strongly convex dorsally, ending with a very short, terminal projection armed with four short upturned spines; telsonic pleura are produced behind the telsonic apex, the margin armed with two or three stout spines and about ten spinules and setae; the sixth pleon pleuron fringed anteriorly and ventrally by about nine curved spines, toothed apically, and two, more posteriorly situated, stout and simple; against the hindermost are three short furcate spinules; this armature apparently increases with age, since in a smaller specimen only six curved spines (all toothed) were present, and the telsonic pleural fringe, too, was less complete.

The *antennule* (fig. 68, *4*) extends to the end of the peduncle of the antenna, the flagellum having five joints, of which the first and last are short. The *antenna* is of moderate length and has, in the male, a flagellum of about twenty-four joints.

The *right mandible* (fig. 68, *6r*), as in several species of this genus, has a small mesial bifurcate piece (suggestive of a much reduced lacinia) at the distal end of the spine row; the third joint of the palp is little shorter than the second and carries about eighteen finely pectinate setae on the distal half of the joint. The *maxillula* appears normal, with about ten spine-teeth and one small setospine on the apex of the outer endite and with two sub-terminal plumed setae; the inner endite with four setospines, but there is only one (the outermost) simple spine present.

The *maxilliped* (fig. 68, *10*), as compared with that of *campestris*, has more brush setae (about fifteen) on the endite of the basis and the endite is rather longer and narrower; the epipodite more setose; the dactyl bears setae on both outer and inner borders.

The palm of the *gnathopod* is armed with about eleven spines, all denticulate (fig. 68, *11*); in the fourth peraeopod, the ischium is relatively shorter, the propod slender, and the palm indistinct (fig. 68, *12(4)*).

The first *pleopod* (fig. 68, *13(1)*) shows a distinct lateral flange on the sympodite, bearing only a single seta; the exopodite not very setose, only about fifteen of the more distal setae being plumed; the endopodite, which rises from a quite narrow base and shows a sub-apical indentation, is little shorter than the exopodite.

The second pleopod of the male is moderately large; its endopodite shows a distinct narrowing at the level of the base of the penial stylet, this latter being long, sparsely setose along its borders, and armed terminally with three stiff setae.

The *uropod* (fig. 68, *15*) is short; the ventral edge of the peduncle has two strong tufts of spines and setae; the inner dorsal edge scarcely armed, except for the two stout spines crowning the low apical elevation; the outer border is rather more spinose, one of the spines, near the end of the peduncle, appearing short and digitate. The rami are unequal in length, the inner nearly as long as the peduncle; both bear two spines in the proximal half of their length; beneath their insertion is an unusually well-developed toothed spine, almost one-third of the length of the outer ramus.

Size. About 11 mm.

Colour. Light brown.

Occurrence. In ditches near sea-level in the neighbourhood of Port Huon, Tasmania.

Very few were taken, and these doubtfully mature. Since they occur on the southern flanks of Mt. Wellington, it might be expected that they would most nearly resemble *campestris* or *thomsoni*; they occur, however, in a different river system, both the Huon and Franklin discharging at Port Huon, and they seem to be quite distinct from *campestris*.

Colubotelson huonensis flynni, sub-sp. n.

(Fig. 69)

Two or three juveniles were taken in January, 1928, by Prof. T. Flynn, from a roadside puddle on Eaglehawk Neck. These, in several features, come near to *huonensis*, of which it is here ranked as a sub-species. The possession (i) of two spines on the proximal half of the outer ramus of the uropod (fig. 69, *15*), and (ii) of a complete series of denticulated spines on the palm of the gnathopod (fig. 69, *11h*) link them with that species, but they differ in that they possess a short and slight penial stylet with but a single apical seta, while the spine beneath the rami of the uropod is relatively much longer, even, than that of *huonensis*.

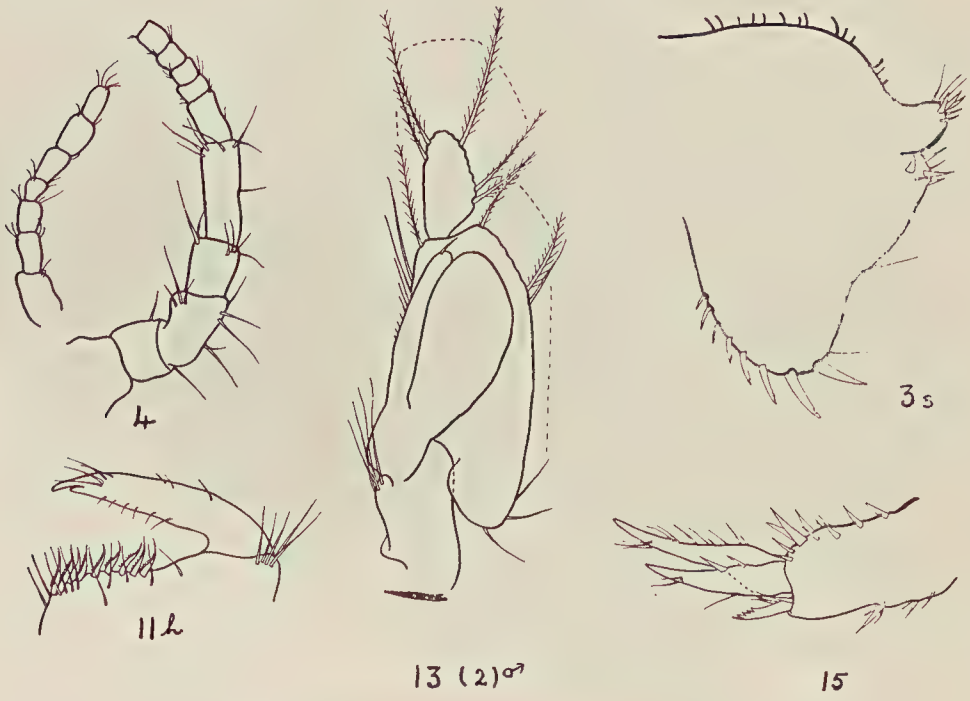


Fig. 69.—*Colubotelson huonensis flynni*, sub-sp. n.

Colubotelson gesmithi, sp. n.

(Figs 70 and 80, *f*)

This species from Mt. Field shows a close likeness to *C. joyneri*, from which, however, it differs recognizably in that it is practically eyeless.

The specific name was chosen to recall the association of Geoffrey Smith with this region, for it was Smith's record of the occurrence of *Anaspides* upon Mt. Field (1909, p. 559) that led the writer to make a search there for Phreatoicids.[1]

In a mounted specimen, an irregular pigmented area can be made out, which obviously represented the eye, and some nine or ten lenses dispersed upon and around the pigmented area could be counted, but the organ was obviously undergoing degeneration. The *antennule*, with its four-jointed flagellum, is even shorter than in *joyneri*, reaching little beyond the end of the fourth joint of the peduncle of the antenna. Only its penultimate joint is swollen. The *antenna* differs slightly from that of other species of this genus in that the proximal three joints are of approximately equal width, the second and third sub-equal in length; the fourth is distinctly more slender than the third and little stouter than the fifth, though shorter than the latter by half its own length. The flagellum has sixteen to eighteen joints, the first nearly as long as the fourth peduncle joint, the terminal joints rather more than half the length of the first joint of the flagellum.

The *upper lip* is rather more than usually asymmetrical, the V-shaped hollow on its posterior face exceptionally long.

The *right mandible* has the usual four teeth on its cutting edge, while the spine-row has a mesial lamina at its distal end particularly well developed; it is minutely denticulated and suggests a vestigial *lacinia mobilis*. The palp, too, is rather generalized, the first and third joints sub-equal, the third having a short brush of setae, finely pectinate and arranged in two parallel rows.

The *labium* has the shape normal for this genus and shows in its mesial fringe of setae at least one setospine in a much reduced condition. In the *maxillula*, the proximal endite has a slightly convex mesial border; the outer endite bears about eleven spine-teeth, and one small setospine apically and two feebly plumed setae on the posterior face. The *maxilla* appears to differ in no noteworthy detail from that of *joyneri* and the *maxillipeds* of the two species are scarcely distinguishable, except that in *gesmithi* the epipodite is more rounded and has about three setules disto-laterally; there are three coupling hooks on the endite of the basis and the propod seems a little less broadened.

No fully-grown male was taken, but in a specimen not quite 11 mm. long the *gnathopod* has a narrow propod, sub-triangular in shape, the very oblique palm nearly thrice the length of the free posterior border. The distal half of the palm is armed with a close-set series of relatively slender, denticulate spine-teeth, twelve to fourteen in number, that half of the palm nearer the dactyl being unarmed. The distal end of the palmar edge of the dactyl is narrowly slotted to give about fourteen close-ranked square-ended teeth (fig. 70, *11h*).

A spent female, about 9 mm. long, bore a gnathopod in which the hand scarcely differed from that described for the male, except that the teeth on propod and dactyl might have been rather fewer in number. The basis of this appendage in the female was practically bare of setae; in the male, on the anterior border, was a sparse fringe of long, slender setae.

---

[1] Actually the credit for the discovery that *Anaspides* existed elsewhere than on the summit of Mt. Wellington should go to G. M. Thomson, *vide* Calman, 1896, p. 802.

The fourth *peraeopod* of the male shows the propod shorter and stouter than that of the preceding appendage, a short, scarcely concave palm defined proximally by two stout spines (fig. 70, *12(4)*); but neither gnathopod nor fourth peraeopod is nearly as well developed as are those limbs in *joyneri*.

In the female the second, third, and fourth peraeopods are stouter and a little longer than the gnathopod; in the fourth the basis is widened, and appears practically without setae, and is little longer than the ischium. The oostegites are large and bordered by a close fringe of long setae.

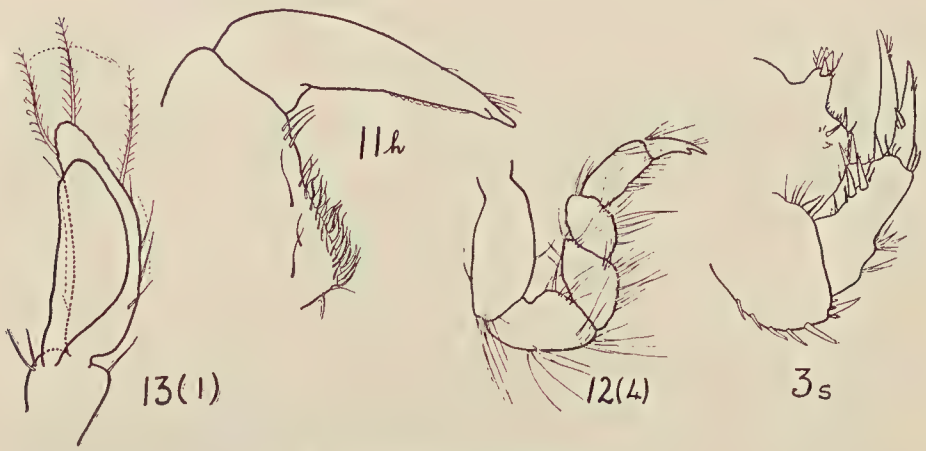


FIG. 70.—*Colubotelson gesmithi*, sp. n.

In the condition of the remaining peraeopods there seem to be no discoverable differences from that of the corresponding limbs of *joyneri*, apart from trifling differences in setal armature.

The male appendage is a short, stout tube, not shaped as in *joyneri*, and bears two or three setae sub-apically.

The first *pleopod* (fig. 70, *13(1)*) lacks the lateral fringe of setae upon the sympodite, but has, instead, one or a couple of spine-setae distally; the appendage is relatively short, the exopodite only sparsely setose, about a dozen of the more distal setae being plumose; both lamellae are quite narrow at their insertion; the endopodite little shorter than the exopodite. In the second pleopod of the male there are sparse setae scattered over the hinder surface of the exopodite; the penial stylet appears much more strongly curved than in *joyneri*, but like that species has three stiff, apical spine-setae.

In the pleon, the pleura of the first to fifth segments are nearly identical in the two species, the setae, perhaps, rather fewer in *gesmithi*, but in the tailpiece there are some differences.

The pleuron of the sixth pleon segment has no more than six spines, of which four (sometimes five) are curved, toothed spines, followed by one (or two) hindmost stout and simple; about the last are grouped four furcate spinules. The apex of the telson is less tip-tilted than in *joyneri*, and is preceded by a wide concavity. The telsonic pleuron projects abruptly and bears two stout spines

dorso-posteriorly, one being sub-marginal; associated with these are two or three spinules, but for the most part the border of the pleuron is unarmed; in one specimen there were several stiff setae on this border.

The vestigial suture between sixth and telsonic pleura is marked in this species by a short rank of four to seven setae.

The *uropod* is short and stout, the depth of the peduncle nearly half its length, its upper, outer border with three or four stout spines; on the inner border two strong spines rise from the apex. Both rami are stout, the outer short, less than two-thirds of the length of the peduncle, with one stout spine at its mid-length; the inner, nearly as long as the peduncle, bears several sensory setae near its end. Beneath the origin of the rami is one stout spine and a second quite slender, both toothed apically.

Size. Largest male barely 11 mm.; female 9 mm.

Colour. Pale greyish-brown.

Occurrence. Taken (January, 1928) from under moss and liverwort in slowly flowing water in ditches crossing the trail up Mt. Field, associated with small examples of *Anaspides*. No specimens were secured in the tarns on the summit.

Colubotelson chiltoni (Sheppard)

(Figs 71 and 80, *g*)

Sheppard, E. M., 1927, p. 105, fig. 7 *(Phreatoicus chiltoni)*.
Smith, G. M., 1909, p. 71, pl. XII, fig. 2 *(Phreatoicus australis)*.

This species was discovered by G. M. Smith in the Great Lake, Tasmania, and, although assigned by him to *P. australis*, was considered as a distinct variety which, however, he neglected to name. Since it has been described by Miss Sheppard in some detail, in the following account only those features will be noted which appear to be distinctive, or of use in instituting comparison with other species.

The *body* is wrinkled slightly and somewhat irregularly; setae are sparse, except as fringing the margins of the pleon segments and, of course, upon the appendages. The *eyes* are moderately large with as many as forty ommatidia. *Antennule* relatively short with, according to Sheppard, a maximum of seven joints, the penultimate not swollen; actually there are frequently five joints in the flagellum and the proportions of the joints then differ from the description given. The *antenna* is nearly one-third of the length of the body; the last three joints of the peduncle are said to be sub-equal; commonly, however, they show progressive increase in length, the fifth being almost twice as long as the third; the flagellum is twice as long as the peduncle and has from fourteen to eighteen joints.

Mouth parts. The *labrum* is quite markedly asymmetrical; the third joint of the *mandible* palp is described as having a double row of setae, one row of simple setae, the other of setae pectinate along one border; actually, in the specimens examined, three rows could be made out, one of which was of short denticulate spinules; there seem to be several setospines in the mesial fringe of setae upon the *labium*. Upon the inner endite of the *maxillula* there is the usual arrangement of two simple, slender spines and four setospines; apically these latter are swollen and unarmed; upon the outer endite there appear to be twelve stout spines and one setospine; sub-marginally on the posterior face are the two slender, plumose setae found in all species of this genus. The *maxilla* has the usual row of filtratory setae ending distally upon the anterior face of the endite, just lateral

to which is a stout, pectinate spine. Posteriorly to the filtratory setae, the row of biting setae are about fifteen in number, and distally these are paralleled by a thick fringe of fine setae; upon the inner of the two distal endites there is a similar short, bushy row of setae. The *maxilliped* is normal, with about thirteen brush setae upon the mesio-dorsal edge of the endite; the epipodite, more elongate than in *australis*, has a lateral fringe of about eighteen setae continued mesially by a fine fur of setules.

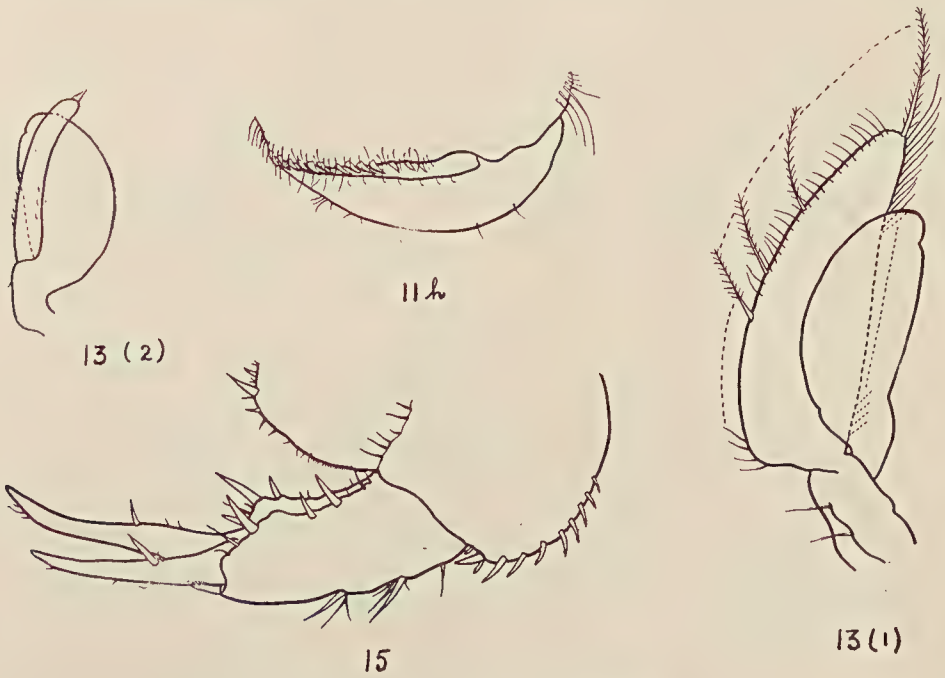


FIG. 71.—*Colubotelson chiltoni* (Sheppard).

Peraeon and peraeopods. The first peraeon segments appear to be more expanded ventrally in the male than in the female. As in *australis*, the postero-ventral corners of the second, third, and fourth peraeon segments are fringed with setae. The *gnathopod* bears upon the palmar border of the propod a row of ten to thirteen short, curved, denticulate spines, these spines extending to the posterior limit of the palm (fig. 71, *11h*), whereas in *joyneri* they are fewer and are replaced near that end of the palm by more slender and non-denticulate spines. The propod of this appendage and of the fourth peraeopod of the male appears less massive than those of the corresponding limbs in *joyneri*.

The condition of the seventh peraeopod approaches more nearly to that figured for *australis*, its basis being little expanded and markedly setose. The male appendage is short and apparently unarmed.

The pleura in the *pleon* are fringed with setae, but differ from those of *australis* in their arrangement and abundance. On the first pleon segment there are few (three to four) setae ventrally, and about as few sub-marginally on the

posterior border; rather more plentiful on the second segment, they become abundant on the third, where they appear both marginal and sub-marginal. The fourth shows a loose fringe ventrally, but they are sparse on the posterior border, while on the fifth pleuron they are represented along the hinder margin by short, fine setae, widely spaced. On all but the first there is a complete fringe of setules interspersed with the setae.

The first *pleopod* (fig. 71, *13(1)*) differs from that of *australis* in that plumose setae are practically absent from the mesial border of the exopodite, but extend more than half-way along the outer border and are much more numerous (about twenty-five) as compared with ten to twelve in *australis*. The endopodites of both first and second pleopods show a terminal emargination like that figured by Chilton for *australis*. In the male, the penial stylet has a short row of spines upon the lateral edge of the scroll-like structure, and a longer row of shorter setae upon its mesial edge; apically, there are but two terminal spine-setae.

The *tailpiece* is relatively longer than that of *australis* and differs from that of both *australis* and *joyneri* in several details. Its apical process seems to differ from the condition described by Sheppard; it is rather wider than long, armed with four longish spines of equal size and a few slender setae. Beneath the apex the backwardly-projecting telsonic pleura are armed with a single, stout spine, two or three spinules, and a few setae and setules.

The sixth pleon pleura are a little variable in their armature; the general arrangement of the spines and spinules is fairly constant, but the number varies from eleven to eight. The spines are, in one specimen, ten, all toothed; in others there are nine or eight of these, but there are stouter spines, simple in character, varying in number from one to three; these latter, as in *australis*, are flanked by two to four short, digitate spinules. The short ridge marking the line of junction between the sixth pleon segment and the telson resembles that of *joyneri* (as also the spines beneath the insertion of the rami). The *uropod* (fig. 71, *15*) is relatively more slender than that of *joyneri*; the armature of the dorsal border of the peduncle is less strong, there being but one long, apical spine; of the rami, the inner is as long as the peduncle. On each ramus there is a stoutish spine at about mid-length, but the associated setae are fewer.

Size. Largest specimen about 14 mm.

Colour. Dark brown with marbling and markings of a lighter brown.

Occurrence. In the Great Lake, Tasmania. Taken by G. Smith (1908/9) and by Tattersall (1914). The species is also plentiful in the Shannon Lagoon, through which passes the overflow from the Great Lake.

Colubotelson chiltoni minor, sub-sp. n.

(Figs 72 and 80, *h*)

A small form, obviously near to *chiltoni*, from which it differs in the following details:—

The *eye* has fewer ommatidia (about sixteen). The *antennule* examined, is short, reaching only to the end of the fourth joint of the peduncle of the antenna, and is unusual in that the first joint of the peduncle apparently represents first and second united—probably a teratological condition—the flagellum with but four joints, the third quite long. The peduncle of the *antenna* is like that of *chiltoni*, but the flagellum has only twelve or thirteen joints.

The *lower lip* shows a rather long setal fringe. The innermost of the seto-spines upon the inner endite of the *maxillula* is somewhat reduced. The proportions of the epipodite of the *maxilliped* differ and the dorso-lateral setal fringe is reduced to about three setae.

The palm of the *gnathopod* has but seven denticulated spines. On the seventh *peraeopod* setae are almost wanting from the propod. The *pleopods* are in too poor a condition to provide much information, but the penial stylet has two terminal stiff setae as in *chiltoni*.

Fig. 72.—*Colubotelson chiltoni minor*, sub-sp. n.

The *tailpiece*, too, is in fairly close agreement with that of *chiltoni*, the telsonic process, wider than long, having four short spines and few (six to eight) setae; below the process, the pleura have each a stout spine dorso-posteriorly and four small flanking spine-setae; the sixth pleon pleura bear eight pectinate spines, the more anterior short and slender, the two hindermost much stouter, and with three small furcate spinules; the junction between sixth pleon and telsonic pleura is marked by a quite short ridge, bearing a single spine. The *uropods* are stout (fig. 72, *15*), the inner border of the peduncle little elevated, and with but a single spine of moderate size situate apically; the outer edge with several spines, one, particularly stout, distally; both rami are stout; of the spines beneath their insertion, one is stout and toothed, the other slender and simple.

Size. Male 10·5 mm. Female (spent) 10 mm.

Colour. Resembling *chiltoni*.

Occurrence. Only a few specimens were seen, these being collected by Miss N. Hutchinson, in February, 1928, from Pine Lake, a small sheet of water on the Plateau, north of the Great Lake. Possibly this should be ranked as a distinct species, but the material was too limited to permit of a satisfactory study.

Colubotelson chiltoni saycei, sub-sp. n.

(Figs 73 and 73A)

This form, taken on the Tasmanian Plateau, seems to be intermediate between *chiltoni* and the North Coast species, *fontinalis*. Unlike the latter, however, it does not show any tendency to degeneration of the eyes. Some half dozen specimens were collected, according to Sayce, by Prof. Baldwin Spencer (probably in 1900) from the waters of a small lake (Petrarch) at an altitude of 2900 ft.

By the kindness of Mr. Kershaw (then Director of the National Museum, Melbourne) the writer was provided with a copy of several pages of typescript, which formed part of the Sayce collection; from this it appears that Sayce had referred these to a new species under the name *Phreatoicus spenceri*, but this description was never published. However, in a note 'On the Crustacean, *Phreatoicus australis*, from Tasmania'[1] Sayce wrote 'Of those received from Professor Spencer, from Lake Petrach,[2] . . . At first I was inclined to regard them as a new species, principally in consequence of the shape of the hand and the armature of the terminal segment, but after examining some specimens of *Phreatoicus australis* from Mt. Kosciusko, sent through the kindness of the Trustees of the Australian Museum, I regard the differences from that species as slight and varietal.'

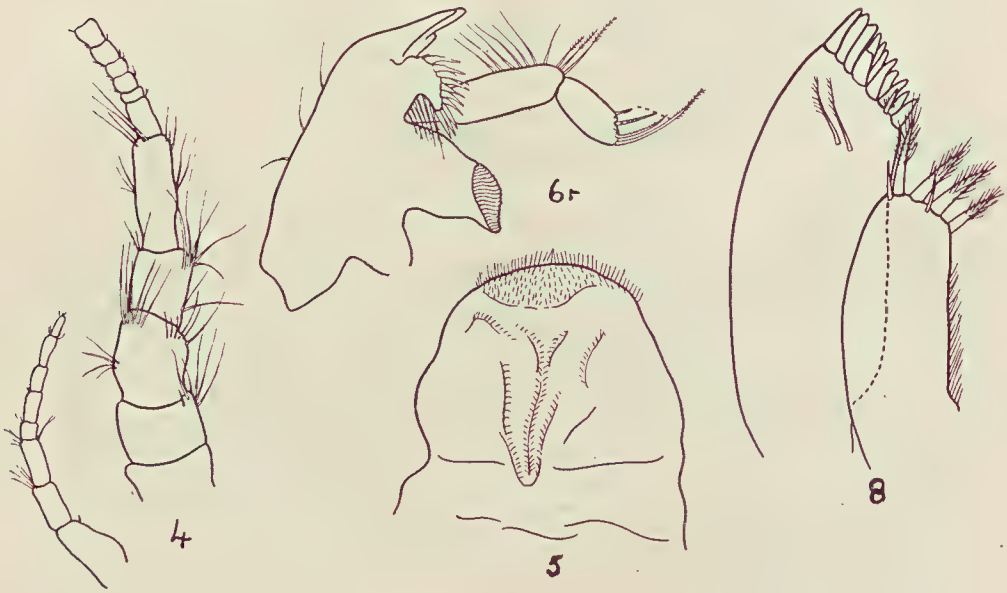


FIG. 73.—*Colubotelson chiltoni saycei*, sub-sp. n.

Sayce's original description was as follows:—'Body stout, sparsely setose. Eyes somewhat large, round. Pleura of first segment of pleon produced to slightly below the coxae of last peraeopod, succeeding four segments with pleura deeply produced, their inferior margins evenly rounded, and fringed with long flexuose setae which extend somewhat along the posterior margins. Terminal segment deeply convex above, and covered with a fur of short setae, the inferior margin possessing nine pectinated spinules that increase in length posteriorly, these, with the exception of the last two, are strongly pectinated at their tips, also at the extreme distal angle there is a bunch of three small pectinated spinules. Projection at extremity of telson prominent, its distal upper margin spinulose.

(1) *Victorian Naturalist*, Vol. 17, No. 6, Oct., 1900, pp. 108-111.
(2) Sayce has misspelt this name in his paper. It should be Petrarch—Ed.

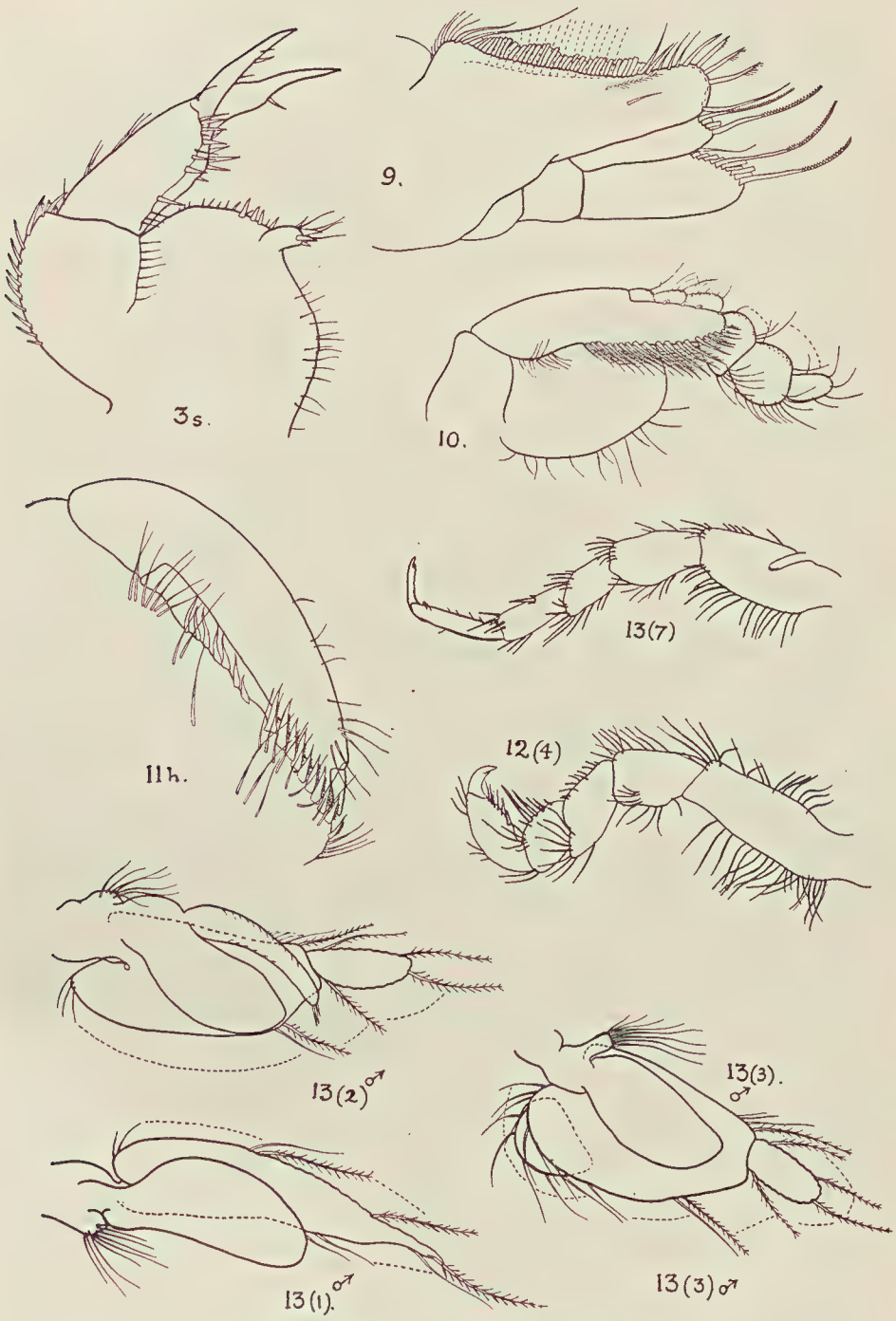


FIG. 73A.—*Colubotelson chiltoni saycei*, sub-sp. n.

'Upper antennae scarcely reaching to extremity of peduncle of lower. Lower antennae less than one-third the length of the body, peduncle scarcely so long as the lower margin of the cephalon, flagellum of about fourteen articuli. First peraeopod with palm oblique, very slightly convex, posterior distal angle slightly rounded off, with thirteen more or less pectinated spine-teeth along the margin, and also a parallel row of simple setae which extend a short distance beyond the palm. Dactyli of all peraeopods furnished on the inner margin with a small secondary unguis. Infero-distal angle of peduncle of uropods with one large broad apically pectinated spine, and two smaller lateral ones.

'*Colour.* Pale yellow with dendroid markings of chocolate brown on body and appendages.

'*Size.* 14 mm. in length.

'*Habitat.* Lake Petrarch (Fresh-water) Tasmania. Elevation 2900 ft.'

In his notes in the *Victorian Naturalist*, Sayce remarks: 'The following differences may be mentioned as observed in the Lake Petrach specimens compared with those from Mt. Kosciusko:—Firstly, the gnathopods of the male have the palm oblique, almost straight, with a notch near the articulation of the dactylus, and the margin is defined by a fringe of 13 triangular spines, that commence just beyond the notch and extend to the postero-distal angle; these spines are strongly denticulated on the edge that faces posteriorly, and the denticulations become more numerous, and also the spines longer and more acuminate, toward the posterior angle. Parallel with this row is a row of simple setae that extend for a short distance beyond the angle along the posterior border. In the Mt. Kosciusko specimens the palm is strongly convex, and, in addition to the row of simple setae, instead of 13 denticulated teeth there are only nine and these are of similar form, but not toothed. This character was constant in each of the specimens examined. Secondly, the terminal segment had the inferior margin fringed with nine spinules (not 15 or 16 as mentioned by Chilton), which gradually increase in length hindwards, and all are more or less pectinated at the tips, with the exception of the last one, which is simple; also, in addition to these, there is distally a sub-marginal cluster of three little pectinated spinules. The uropoda are similar to Chilton's drawing, with the addition of having a very conspicuous long spine at about half-way along the upper margin of each ramus. In other respects of form they essentially agree.'

Actually, there are a number of other differences which serve to distinguish it from the Tasmanian Great Lake species, *chiltoni*, as well as from *australis*. If, however, as is probable, Sayce's description was accurate for the specimens dissected by him, the form must be somewhat variable.

Thus, in the gnathopod, there were found in the specimens examined only ten denticulated spines followed, in the anterior part of the palm, by seven more reduced spine-teeth, lacking denticulation (fig. 73A, *11h*). Sayce's reference to the condition in *australis* is, however, in error, for the teeth upon the palm on that species, though fewer (eight to nine), are all very strongly denticulated. Again, the pleura of the sixth pleon segment may bear as many as thirteen curved spines, terminally toothed, instead of nine, as stated by Sayce.

These and other details are shown in the several figures. In the telsonic apex this sub-species agrees with other *Colubotelson* forms and differs from those of *Metaphreatoicus* in that only four terminal spines are present.

Colubotelson fontinalis, sp. n.

(Figs 74 and 80, *i*)

This Phreatoicid, which is found abundantly on the central part of the North Coast of Tasmania, at levels little above that of the sea, is superficially so like *chiltoni* that it was originally considered a sub-species only. A closer examination, however, has revealed a number of differences.

Many examples are practically eyeless, the eye being small in some, while in others it appears, in life, as a chalky white area, a condition which is associated in many Crustacea with the obsolescence of this organ.

The antennule normally has only five joints in the flagellum; the antenna resembles that of *chiltoni* in peduncle and in the elongation of the more distal joints of the flagellum, but the proximal joint is quite short; there may be as many as twenty-five joints in the flagellum. Asymmetry in the labrum is well marked.

The mandibular palp is relatively long; the setae in the distal half of the third joint are set in three rows; those in one row are denticulate; in the others they are finely pectinate on one side. Proximal to the spine row are four plumed setae; the molar on the right mandible is elongate (fig. 74, *6r*).

Sheppard's figure (1927, fig. 3 (6)) of the labium of *tasmaniae* would serve equally for this species.

The maxillula (fig. 74, *8*) is a little unusual in that the inner endite widens at about the middle of its length, its mesial border there being convex, and then contracts, becoming concave distally. The outer endite has about ten apical spines, the accompanying setospine being very small; the two plumed setae on its posterior face lie near the mesial border; in some species (e.g., *affinis*) they are much more laterally placed.

The maxilla shows the middle endite as the shortest. In the maxilliped the propod appears much more expanded than is figured by Sheppard (1927, fig. 7 (5)) for *chiltoni*, and the epipodite has a more extensive fringe of setae.

Sheppard's figure (1927, fig. 7 (6)) for the gnathopod of *chiltoni* omits details of the hand, but a comparison of the actual appendages of the two forms show differences in the shape of the propod and in the armature of the palm. In the specimen figured (fig. 74, *11h*) it was found that in *fontinalis* the propod is more sub-triangular in shape, the maximum length and width sub-equal, the palm convex (it is straight in *chiltoni*) and sharply marked off from the posterior border, which is short; the denticulate teeth become simple, conical spines as the dactyl is neared, and they extend (unlike the condition in *chiltoni*) almost to the base of the dactyl.

The fourth peraeopod in the male bears a propod almost unmodified in shape, showing no recognizable palm, but an exceptionally stout spine evidently receives the strongly curved dactyl (fig. 74, *12(4)*).

The pleon pleura generally are fringed with shorter and far fewer marginal setae than are found in *chiltoni*, except in the case of the fifth in which the posterior border has this fringe better developed.

The first pleopod bears on the outer border of the exopodite a sparse fringe of simple setae as well as the normal rank of plumose and pectinate setae; it differs from other species, however, in that it bears one stiff spine near its outer distal end, recalling, in this, a condition found in *tasmaniae*. The penial stylet differs, too, from that of *chiltoni* in bearing three stiff, terminal spine-setae.

In the tailpiece several differences are to be noted: the free border of the sixth pleuron bears the same number of spines as in *chiltoni*, but the two hindermost are usually stouter and shorter and generally free from terminal teeth; there is a rounded junction of the pleuron with the telson beneath the apex instead of the usual angular one; the normal sub-marginal spine is closely approximated to the marginal, and both are stouter than in *chiltoni*. The uropod is unusual in that its outer ramus retains two spines well separated (fig. 74, *15*), a feature which characterizes some species of *Mesacanthotelson*, and is seen also in *Crenoicus*.

Size. 12·5 mm.

Colour. In life rather paler brown than *chiltoni*.

Occurrence. First taken (1928) in ditches in a field adjoining the railway station at Lemana Junction. Subsequently (1929) found in various nearby localities, including springs in the hillside and, also, abundantly in almost every ditch for some miles around Deloraine.

The occurrence of this Isopod on the North Coast of Tasmania is of considerable interest. G. Smith stated (1909) that Phreatoicids were apparently entirely absent from the North and West coastal regions of the island. It would seem likely that a generalized *Paraphreatoicus* was once widespread on the island, south of and including the Plateau; that in the Great Lake and adjacent lakelets it underwent some modification, giving rise to *intermedius*, *chiltoni*, etc., and that some of these, reaching the North Coast by way of the Mole, gave rise to the present species. The occurrence of many blind or purblind examples seems to lend support to this view.

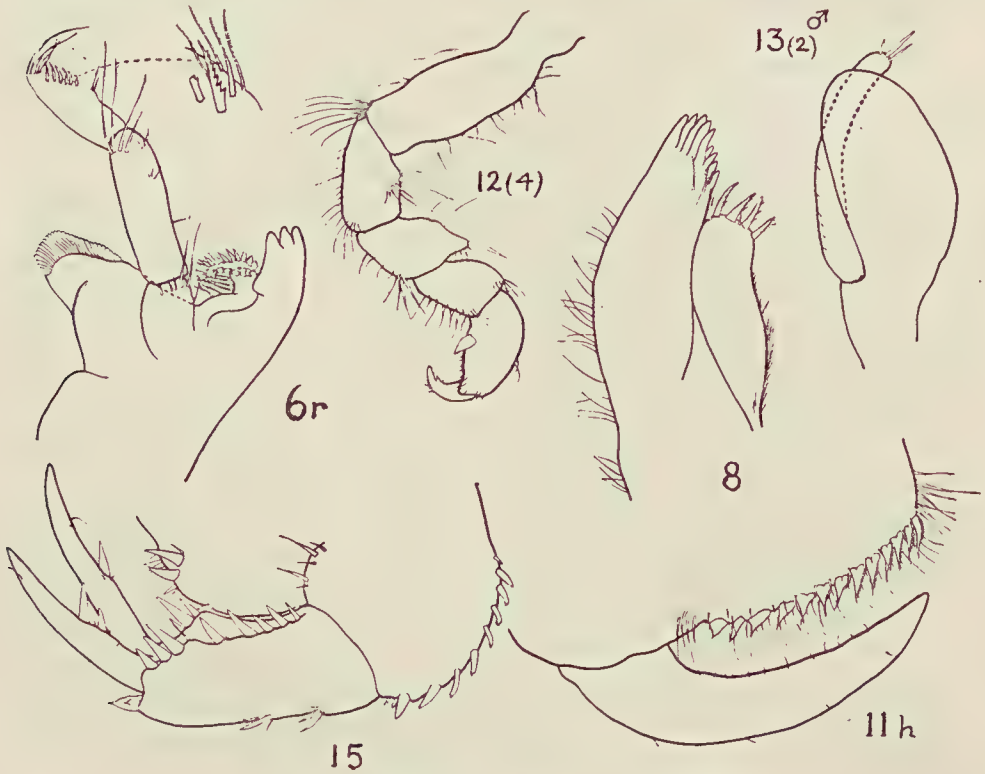


FIG. 74.—*Colubotelson fontinalis*, sp. n.

Colubotelson tattersalli (Sheppard)

Sheppard, 1927, p. 102, text-fig. 6 *(Phreatoicus tattersalli)*.

From the outset, all attempts to recognize this species proved unsuccessful, and although, eventually, several thousands of Great Lake specimens were examined, not one was found which has conformed to the description given, nor which could, with reasonable certainty, be referred to it.

From correspondence between the author and Miss Sheppard shortly after the appearance of her paper, it would appear that there must have been very few of this species represented in the collection made in 1914 and upon which the description was based. It seemed possible that it was never an abundant form and that the changes brought about in the Great Lake consequent upon the damming effected by the Hydro-Electric Commission had resulted in the practical extinction of the species. It was not recorded by Geoffrey Smith in the summer of 1907/8, nor was it found by the writer in the considerable collection made by Professor Flynn in 1917 when the construction of the dam had been but recently completed.(1)

The task of identification was rendered more difficult by the incompleteness as well as a certain vagueness of the description. Precise statements were largely limited to such details as the numbers of joints in appendages (e.g., antenna) which, as already repeatedly noted, are commonly liable to a wide range of variation, or the proportions of the joints of the peduncle which are frequently not distinctive. Moreover, the apparently characteristic feature in the second antenna, viz., the sub-equality of a long first joint of the flagellum with its penultimate joint is one which, frequently, cannot be made use of, for not only are the terminal joints commonly lost in preserved specimens, but the first joint may subsequently undergo further segmentation. Information on diagnostic features, such as the condition of the mouth parts, peraeopods, and pleopods is, in the main, limited to statements that they bear a resemblance to those of *tasmaniae* or are similar to those of *P. australis*—general statements which could be made for many Phreatoicids and which are of even less use when some of these parts (e.g., maxillipeds) have not been fully or correctly described. Finally, a description of the pleopods and uropod has been completely omitted, the figures providing little useful information.

Thus from Sheppard's description there proved to be available for identification only the following details:—*Body* slightly sculptured or ridged; the surface covered with tufts of short hairs and scattered setae.

Head sub-equal in length to the combined length of the first and second peraeon segments; eyes lateral, with thirty to forty facets. The first *peraeon* segment half the length of the second, which is sub-equal to the third and fourth; fifth, sixth, and seventh might be presumed sub-equal, being described as slightly shorter than the fourth. The first pleon segment is but half as long as the seventh peraeon segment; second, third, and fourth segments show a slight progressive increase in length, while the fifth is twice as long as the fourth. The pleura of the second, third, and fourth pleon segments have a depth greater than that of their segments.

The *tailpiece* (sixth pleon segment and telson) is slightly convex above; the terminal projection, a little longer than broad, is tipped with *two* spines placed laterally, and eight longer setae; the telsonic pleuron is rounded and bears eight

(1) The outflow of water from the Great Lake passes through a grid which prevents the escape of fish. Periodically this is raised for cleaning, and Flynn's collection was made by scraping its surface. It should, therefore, have been a fair sample of the free-living Phreatoicid fauna.

spines, of which the fourth is larger than the others; the pleuron of the sixth pleon segment bears a large spine distally and, preceding this, five *longer* spines, each of which bears two minute, sub-terminal teeth.

Appendages. Antennule with flagellum of five joints, nearly as long as the peduncle of the *antenna*. This latter has first to third joints short, the third being produced slightly on the inner side, the fourth equalling the combined length of the second and third, the fifth once and a half as long as the fourth; its flagellum has sixteen joints, of which the first is long, being half the length of the fifth (i.e., the longest) joint of the peduncle, the second shorter (only one-third of the length of the first), subsequent flagellar joints increasingly long till the penultimate joint is practically as long as the first; the appendage is nearly one-half of the length of the body.

In the *mandible*, the third joint of the palp is said to bear a double rank of setae, the first rank made up of simple setae, the second of setae pectinate along one border, a condition recalling that of *M. decipiens*, where, however, the second row consists of short, toothed spinules.

The outer endite of the *maxillula* has only nine spiniform setae, some minutely denticulate, while the distal part of the fringe of setae on both inner and outer margins is noted as long. The occurrence of two sub-apical plumose setae is recorded; this is, however, not a feature peculiar to this species but one found in very many Phreatoicids.

In the *maxilla*, the proportion of the lobes is not unusual, but the exceptionally thick teeth on the pectinate setae of the outer lobes may have value as a distinctive character.

There are no details of gnathopods or of sex differences, except for a passing reference to modification of the fourth peraeopod in the male.

Some other details might, perhaps, be gleaned from the figures. Thus the *habitus* figure shows the peraeon segments deeper than long, which is an important feature, and characteristic of *Mesacanthotelson*; the figure is very small and perhaps it should not be relied upon for detail, for it shows the seventh segment not only longer than the sixth, but actually as long as the third segment, which not only seems quite improbable but is, indeed, contradicted by the text.

The same figure suggests, too, that the transverse ridges are really very slight indeed, and setae appear to be practically wanting, a suggestion which is borne out by the more highly magnified figure of the tailpiece; but in the text there are said to be scattered setae, which are most abundant on the dorsal surface of the telson. The *habitus* figure shows the telsonic projection sharply upturned, and this would be a highly distinctive feature. It is, however, in sharp conflict with the enlarged figure of the tailpiece, which indicates the projection more backwardly directed, rather as in *Colacanthotelson*.

Another important feature, and one which should perhaps be sufficient to exclude *tattersalli* from that genus, is the marked degree of expansion of the basis of the seventh peraeopod. This joint appears narrow in the *habitus* figure, but in the enlargement drawn by Miss Sheppard (1927, fig. 6 (4)) from the appendage removed, its real width is shown as almost exactly one-half of its length, and those are the proportions shown by Chilton for *australis*, to which species Sheppard likens *tattersalli*.

As regards the sculpturing and, more particularly, the transverse ridging of the segments, the description of this species suggests a kinship with *tasmaniae*, *setosus*, and *decipiens*, from all of which, however, it should be readily distinguished

by the condition of the tailpiece and especially of the terminal projection, which is said to have but a single pair of latero-terminal spines. As already stated, these details are not confirmed by the figures.

An armature of spines, such as that recorded for the terminal projection of *tattersalli*, has been found elsewhere only in *pearsoni*; but that species differs in its smooth body, in other details of the tailpiece and in the proportions of the joints of the antenna, palp of mandible, etc.; notably, too, *pearsoni* differs from all other recorded Great Lake species in the condition of its uropod with its huge dorso-mesial projection, and while it is most unfortunate that a description of this appendage was omitted from the description of *tattersalli*, it is, nevertheless, scarcely credible that Miss Sheppard would have overlooked such a significant character had it been present; her figure (1927, text fig. 6 (11)) shows no suggestion of such a structure. Moreover, as already pointed out, such a condition of the uropods seems to be invariably associated with a burrowing mode of life, and *tattersalli* is said to be a shore-haunting form living under stones. The small size recorded for *tattersalli* suggests that Tattersall's specimens may have been immature. Of *pearsoni*, my smallest examples are about 11 mm. in length, but apart from increase in size and developments related to sex, there is found neither significant change that could be attributed to growth, nor distinctive characters absent in the half-grown. The possibility, therefore, that *tattersalli* could be the immature condition of *pearsoni*, may be entirely dismissed.

In the collection made by Dr. J. W. Evans and deposited in the Tasmanian Museum there were a few specimens which Dr. J. Pearson provisionally had attributed to *tattersalli* and, if one could substitute the word 'spines' for 'setae', could regard the ridges referred to as much more strongly developed than is indicated in the *habitus* figure (1927, fig. 6 (i)) and, further, could suppose that, in the specimens originally examined, two of the telsonic spines were either incompletely developed or had been lost—then these specimens come nearest to fitting into Sheppard's description. As it is, they more nearly resemble *tasmaniae*, and they differ, further, from *tattersalli* in other details of antenna, mouth parts, the slenderness of the basis of the hinder peraeopods, and the length of the telsonic process. They have been described in this account under the name of *M. fallax*.

Size. 10 mm.; pleon long, equalling combined length of head and peraeon.

Colour. Dark brown in spirit material.

Occurrence. Todd's Corner, Great Lake (under stones along the shore).

Colubotelson tattersalli dubius, sub-sp. n.

(Fig. 74A)

The specimens recorded under this name were collected by the writer from beneath stones in the bed of an almost dried-out creek draining into the Great Lake at Todd's Corner, the type locality for Miss Sheppard's species *tattersalli*. In some particulars these seem to agree well with that author's account of *tattersalli*, but in others they depart quite markedly from that description and, in these latter characters, they approach the condition found in the Great Lake species *chiltoni* and *intermedius*.

It may prove that certain features recorded by Miss Sheppard for *tattersalli*, particularly those which seem to distinguish it from the variety under consideration,

are not constant. In that event the new varietal name will be redundant and the details furnished here will then serve to supplement the rather nebulous original description of the species.[1]

The length of the body is approximately six times the width, the pleon being about as long as the combined length of the second to seventh peraeon segments. It is practically devoid of ridges but is setose, the setae being generally slender and rather long; they form a fringe, sub-marginal in position, on all the segments, but since they are stiffly upstanding they are liable to be overlooked. In the peraeon segments there is an anterior as well as a posterior fringe, the two being linked by a ventro-lateral series. Upon the fifth pleon segment there is, at its mid-length, an additional transverse row, while upon the tailpiece there may be two short ranks of setae limited to the lateral surfaces; in profile this region appears to have a sparse covering of setae. The pleura in the pleon have a close-set free marginal edging of quite long setae; shorter setae, in an interrupted rank, stretch along the antero-posterior axis of the coxae of the peraeopods, this series being continued forward as a short ventro-lateral rank on the head.

The head, which is about as long as the combined length of first and second peraeon segments, has a moderately convex dorsal profile, of which the fairly prominent eyes do not form part; a small pre-ocular lobe projects in front of the eye, bounded below by a fairly long sub-ocular incisure which practically reaches the lower border of the eye; behind the latter is a well-marked depression, from which arises a short genal groove. The anterior (transverse) border of the head is moderately shallow, the inter-ocular space being about twice the longest diameter of the eye, which has probably rather fewer than forty ommatidia. The cervical groove is well marked; it is incomplete dorsally, while its ventral end is obscured by the forwardly projecting coxa of the gnathopod.

The first peraeon segment is scarcely half the length of the second; the second and third are sub-equal, the fourth a trifle shorter, while the fifth, sixth, and seventh show a progressive decrease in length. From the first to the sixth there is a steady increase in depth, but the seventh deepens abruptly.

The first pleon segment has a length about two-thirds that of the last peraeon segment; the second, third, and fourth are progressively longer, the fifth being rather less than the combined length of the third and fourth and rather less deep than those segments. A slight excavation, distinctively coloured, marks the junction posteriorly of the pleura and terga of the first four of these segments; in the case of the fifth there is a quite deep notch; the pleura of the second to the fifth are wider and nearly twice as deep as the related terga.

In profile, the tailpiece is scarcely convex dorsally, but sub-terminally it is sharply downturned (almost incurved) and is then produced abruptly into the upturned telsonic apex. In its inclination to the long axis of the body this process agrees much more nearly with the condition shown in the *habitus* figure given by Miss Sheppard (1927, fig. 6 (i)) than with the enlargement (l.c., fig. 6 *(11)*) of the tailpiece. The actual apical projection examined from below is found to present a convex postero-ventral surface which is as wide as long. Its terminal free border is almost semi-circular and bears four stout spines about equally spaced,

[1] But in the comparative fewness of the spine-setae constituting the armature of the free (ventral) border of the sixth pleon segment of *tattersalli* there is a condition which, while it is met with in no other species of this genus, is characteristic of *Mesacanthotelson* and *Colacanthotelson*: and in the two-spined condition of the telsonic apex, a feature peculiar, amongst Phreatoicidae, to *tattersalli*. It may be, therefore, that the writer is wholly in error in associating this variety with Miss Sheppard's species.

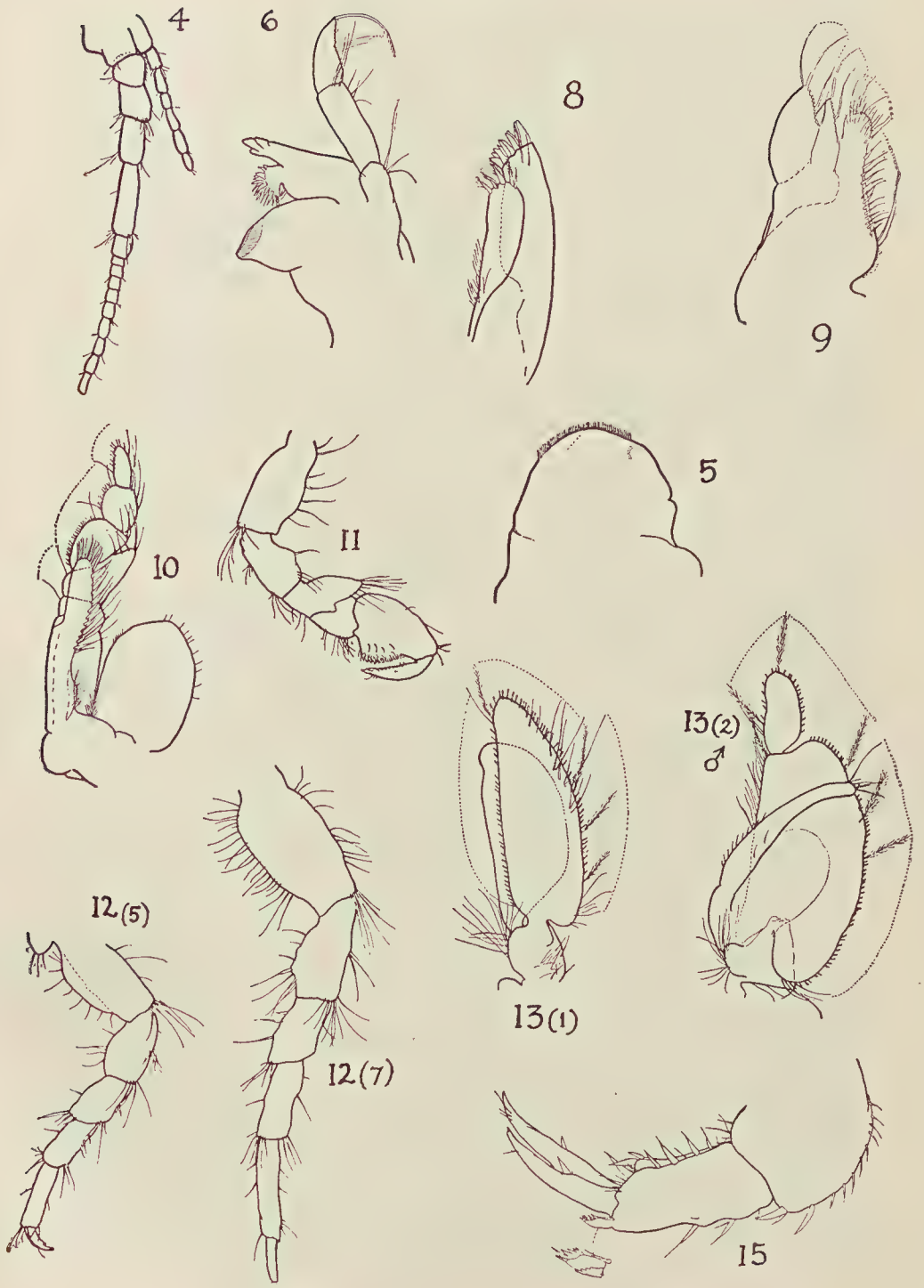


FIG. 74A.—*Colubotelson tattersalli dubius*, sub-sp. n.

interspersed with some stiff setae. In this particular, therefore, these specimens differ markedly from those described by Miss Sheppard, and approach much more nearly to the condition seen in *intermedius*.

The crevice separating the anterior mass of the tailpiece from this apical process appears almost U-shaped, but widens above. On either side it is continued downwards as a shallow groove marking the junction of telsonic pleura with the axial region. These pleura have a distinctly convex posterior border bearing a stout spine at about one-third of its length from its dorsal end; this spine and another which rises sub-marginally both spring from a longitudinal ridge which crosses the shallow lateral extension of the crevice. Dorsal to the stout spine there are usually three slighter spines upon the pleural border, ventrally there are five or six short, stiff setae.

The suture between sixth pleon segment and telson runs antero-dorsally from the hinder border and bears a short, broken, comb-like row of from five to seven stiff but slender setae. The dorsal limit of the insertion of the uropod lies a little ventral to this suture. The armature on the ventral border of the sixth pleon pleuron is slightly variable. It may bear ten to twelve stiff, curved spines, of which the hindmost is the strongest, but is shorter than the three immediately preceding it, in this agreeing with the condition described for *tattersalli*, in which, however, not more than six of such spines are present.

Appendages. The *antennule* is short, extending little beyond the fourth joint of the peduncle of the antenna; its flagellum may have four or five joints. Where but four are found the first and last are short, the second and third as long as the third peduncle joint. The *antenna*, too, is moderately short; the first three joints of the peduncle are sub-equal, the fourth a little longer than the third, the fifth practically equal to the combined length of third and fourth; the flagellum has twenty or more joints, but the first is short, little more than a quarter of the length of the fifth joint of the peduncle, and the succeeding articles are squarish, beginning to lengthen at about the tenth, the terminal joints elongated.

The *labrum* is strongly asymmetrical. The right mandible bears the usual four cutting teeth; the spine row shows a stout, short, double spine at its distal end; the strong molar seems to lack the bushy setae found in *intermedius*; the palp is short, the first joint with a small tuft of setae, the second rather long with a few setae distally, the terminal joint two-thirds the length of the second, with setae in a single row confined to its distal half, and with a terminal seta of unusual length.

The *maxillula* displays the normal condition for species of this genus; the inner endite bears but four apical setospines with short, stiff, simple spines against the first and third; the outer endite has a double row of conical spines, twelve in number, set in a double row; the setospine usually associated with these is unusually large. In the *maxilla* the row of pectinate setae (backing the row of filter setae) is well developed, consisting of thirteen or fourteen setae; a single spine with few pectinations is present on the hinder face of the endite; the apex of this inner endite is rounded and its posterior face is setose sub-terminally; the middle lobe is narrow, the outermost broad; both are armed with an oblique rank of biting setae; setae are apparently absent from the outer border of the appendage, but are plentifully developed just within the margin along the entire hinder surface of the third joint.

On the *maxilliped* the epipodite has but few (nine to ten) setae on its latero-distal border. The *gnathopod* of the male has the basis expanded anteriorly, the width of this joint being more than half its length, its anterior border armed with

a half-dozen long, slender setae; the sub-triangular propod with sinuous palm has ten to a dozen slender, denticulate spine-teeth in a close-set series, while the stout dactyl has a nearly straight, distinctly toothed, palmar edge, its claw supported by a strong secondary unguis. It is quite distinct from that of *intermedius*.

In the posterior group of *peraeopods* the basis is produced into a thin expansion, rising from its posterior border, the width of the joint being rather more than half its length; both borders are set with long, slender setae.

In the first *pleopod* the exopodite is strongly setose, the inner border being fringed with long setae, those situated sub-apically being plumed, and plumose setae extend along most of the outer margin, interspersing the numerous simple setae, a few of which arise sub-marginally; the endopodite is well developed, four-fifths as long as the outer lamella, in this differing markedly from *intermedius*.

In the male the second pleopod bears a rather long penial stylet, narrowing somewhat apically and armed terminally with four stout spines; its mesial border has a short series of curved setae; the sympodite has a well-developed coupling lobe with a strong tuft of entangling setae.

The *uropod* is stout, not greatly produced into a vertical mesial border which is armed apically by one stout and one smallish spine. The outer border is nearly parallel with five or six stout spines; beneath the insertion of the rami is one strong denticulate spine and a second rather small but otherwise similiar; the ventral edge of the peduncle bears two groups of spines and setae. The inner ramus is sub-equal in length to the peduncle; the outer shorter by one-fifth of its length; both bear a single spine at approximately mid-length.

Size. The largest specimen (♂) had a length of nearly 14 mm.

Colour. Very dark brown, appearing, when collected, almost black; the bases of peraeopods heavily pigmented.

Occurrence. Found only under stones in a creek draining into the Great Lake at Todd's Corner.

It should perhaps be noted that when Tattersall's collection was made, the Great Lake had not been dammed. According to recent information, very much of the large bay now known as Todd's Corner was, in 1914, swampy land traversed by the abovementioned creek. The original shoreline was, thus, some distance from that existing to-day. The only part of the habitat of this species which was unaffected by the changes resulting from the damming of the Great Lake would be the persistent part of this creek, in which the variety *dubius* was secured. The present shoreline is practically free from stones, etc., and no Phreatoicids were taken in such situations along the water's edge; dredging, too, in shallow waters gave no material, excepting that of an Amphipod, yellowish green in colour, apparently not hitherto observed.

Colubotelson intermedius, sp. n.

(Figs 75 and 80, *k*)

In 1923 the writer received a collection of Phreatoicid material from the Great Lake. This collection, which was secured by Professor Flynn in 1917, contained some examples of an unrecorded form which was provisionally labelled *intermedius*. In 1927, after the publication of Miss Sheppard's 'revision', this material was re-examined and the form *intermedius* was doubtfully identified as Miss Sheppard's species *tattersalli*. In later collections made by the writer (in

1928 and again in 1929) along the shore of the Great Lake and also in the Shannon Lagoon, this new form was found relatively abundant. A visit to London in 1929 permitted of a comparison of this with the types of *tattersalli* in the British Museum collection. The examination was necessarily superficial, since it did not include a dissection of *tattersalli*, but it seemed to establish the distinctness of the new form. In further material collected by Miss Spargo from the Great Lake between 1932 and 1934, and still later, in material from the Great Lake brought together by the Biological Survey in 1939, this new form had become preponderant.

The following is a description of the new species—*Body* smooth, or with very slight sculpturing, fine setae scattered generally over the body. The eyes are as large as, or even larger than, those of *chiltoni* (about fifty ommatidia). The proportions of the several peraeon segments are a little variable, but, in general, they conform to Miss Sheppard's account of those of *chiltoni*. As already noted, the seventh peraeon segment is shorter than the sixth or fifth and not sub-equal or longer as figured for *tattersalli*. It is, however, in the tailpiece that an intermediate condition of the characters of *chiltoni* and *tattersalli* is apparent. Setae are scattered generally but not in tufts. The telsonic process is rather longer than that of *chiltoni* and tends to project rather more backwardly as figured for *tattersalli* (1927, fig. 6 (11)), but is wider at the base than it is long. Its apex

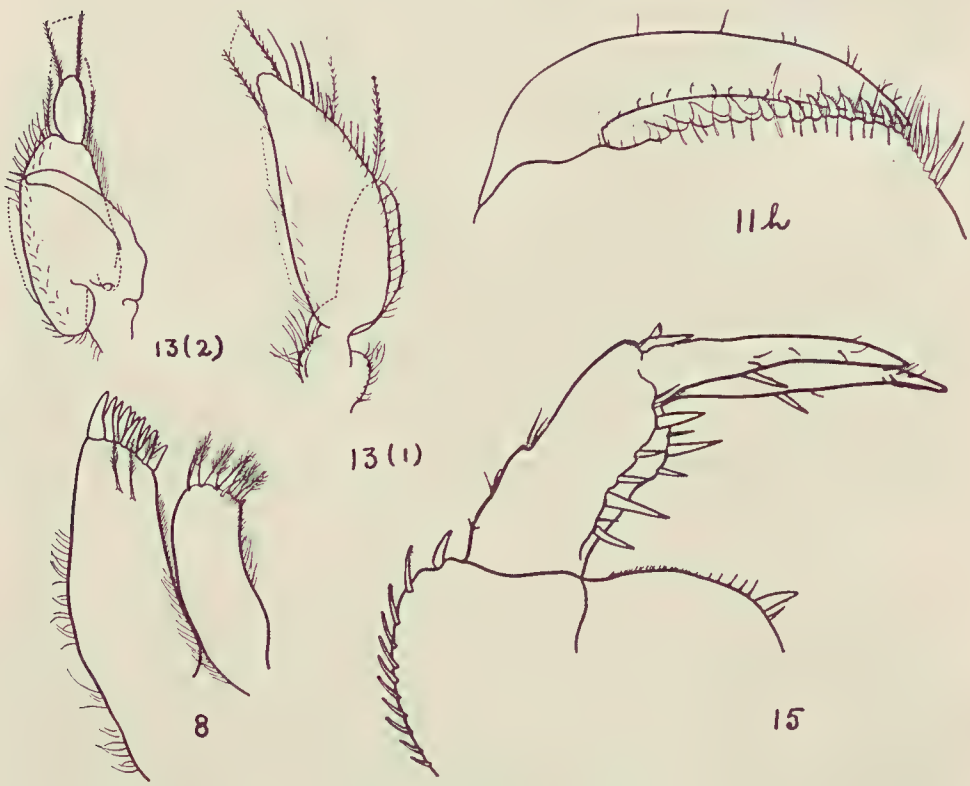


FIG. 75.—*Colubotelson intermedius*, sp. n.

is distinctly convex and furnished normally with four quite long, stout spines and a few setae of variable length. Rarely three spines are found, but never two, the number recorded by Miss Sheppard for *tattersalli*. Beneath the process, the telsonic pleura project evenly rounded (instead of an angular outgrowth following an intervening gap as in *chiltoni* (l.c., fig. 7 (8)). Its armature is a fairly even fringe of seven or eight spines or stout setae with interspersed fine setae. Of this series usually one, the fourth (rarely fifth or sixth), is stouter than the rest and, at the same level, is a stout sub-marginal spine. The arrangement of the antero-ventral fringe of spines comes near to that of *chiltoni* but is variable, frequently differing on opposite sides of the same specimen. There are, as a rule, eleven of these curved, toothed spines, increasing progressively in length and stoutness from before backwards. The last member of the series is frequently markedly stouter than the rest and may be simple.

Appendages. The *antennule*, like that of *chiltoni*, has peduncle and flagellum sub-equal; it is eight-jointed and bears olfactory cylinders on the distal four. The *antenna*, too, agrees rather closely with that of *chiltoni*, the fourth joint of the peduncle a trifle longer that the third; the fifth slender, but not as long as the combined length of the third and fourth; the flagellar joints (there are twenty-five) decrease steadily in thickness without any noticeable increase in length. The *labrum* is distinctly asymmetrical.

In the *mandible* (right) the second joint of the palp is rather long, the third agreeing generally with that of *chiltoni*. From the surface of the molar a short brush-like seta projects.

The *maxillula* (fig. 75, *8*) is unusual in that there are frequently five terminal setospines on the apex of the inner endite, with the usual two stiff, simple spines against the first and third setospines. The outer endite shows ten spine-teeth and a rather long setospine and the normal two sub-terminal plumose setae.

The *maxilla* is normal, but the single spine on the anterior face of the proximal endite is quite long and, as usual in this genus, shortly pectinate. There is an unusual development of the setae at the base of the third segment. The *maxilliped*, like both that of *chiltoni* and of *tattersalli*, bears a series of setae completely round the lateral border of the epipodite. In the male, upon the palm of the *gnathopod* (fig. 75, *11h*), of the row of spine-teeth, only seven (sometimes eight) are denticulated, and there are substituted for the more distal members of this series in *chiltoni* four or five particularly stout, sub-triangular, simple teeth.[1] The shape of the propod is quite nearly that figured for *tattersalli* (1927, fig. 6 (6)), but the free posterior border is concave. Upon the anterior border of the basis of this limb, as, also, upon that of the succeeding limbs, a sensory seta is found, and in the case of the fourth *peraeopod* there are at least three of these. The propod of the latter limb is stout, with a well-marked palm and the usual two spines, the dactyl stout and curved strongly with a well-developed secondary unguis.

In the hinder group of peraeopods the basis shows a slight expansion; in the seventh limb the length of the joint is just twice the greatest width; the appendage is rather more spinose than in *dubius*. The male appendage is short, curved, and bears several setae.

The first and second pleopods (male) display a marked contrast in size between exopodite and endopodite (fig. 75, *13 (1), (2)*). In this they differ from *tattersalli*, at least as far as the first pleopod is concerned, this alone being figured by Sheppard

(1) The condition and armature of the palm of the gnathopod of *tattersalli* is not recorded.

(1927, fig. 6 (7)). It might be inferred that they differ, also, from those of *chiltoni*, Sheppard stating that in that species they are rather narrow, but otherwise like those of *P. australis*, in which species Chilton shows first pleopod with exopodite and endopodite almost equally long. The endopodites lack, also, the terminal emargination of *australis* or *chiltoni*.

The exopodite in both these pleopods bears a heavy marginal fringe of setae, many being plumose, with a sparser sub-marginal series of simple setae, not seen in *dubius*; there are, also, short setae scattered on the face of the lamella near its outer (lateral) border. The sympodite is long, expanded laterally and fringed with long setae upon both inner and outer borders.

In the second pleopod, the penial stylet is long and curved, with a few setae proximally and mesially; as in *chiltoni*, it usually bears but two terminal spine-setae, although there may be a short third spine.

The peduncle of the *uropod* is stout (fig. 75, *15*), its length more than twice its depth; at the distal end of the inner border both apical spines appear, but only one of the two is strong; the outer border bears five or six spines of variable length. Of the two rami the outer is practically as long as the peduncle, the inner distinctly longer; both bear scattered tufts of setae and a single spine near the mid-length; beneath the insertion of the rami are two strongly toothed spines.

Size. Largest male about 15 mm.

Colour. In life, brownish or greyish brown. Upon the bases of the *peraeopods* pigment is distributed only in fine veinings. After prolonged preservation in spirit, fading to pale yellowish brown.

Occurrence. Abundant in the Great Lake and in the Shannon Lagoon.

Colubotelson setiferus, sp. n.

(Figs 76 and 80, *j*)

This, although showing marked resemblances to *C. joyneri*, is, nevertheless, a quite distinct species.

The body is very slender, almost vermiform, free from wrinkles and but sparsely setose; the head short, the front steep, with well-marked sub-ocular incisure and cervical groove. The eyes are small, the ommatidia being represented by a few small and scattered black-pigmented spots. The peraeon has the first segment short but considerably expanded below, the large first coxa overlapping the hinder angle of the head; succeeding peraeon segments are relatively long and deep. In the pleon, the segments have much the same relative lengths as those of *joyneri*, but appear somewhat deeper, and long, flexible setae are continued sub-marginally high up on the hinder borders of the pleura. The tailpiece is more setose; the telsonic process, gently rounded behind, is as long as broad, with a terminal armature of four stout spines and numerous setae; the telsonic pleura project prominently and bear three spines dorsally and a sparse fringe of setae posteriorly, this series including one spine; the sixth pleon segment has an edging of setules antero-dorsally, which gives place ventrally to a rank of nine toothed spines, the hindermost three stout and much the longest; flanking the last are one or two furcate spinules. The junction of the sixth pleon pleuron with that of the telsonic is marked by a slight ridge bearing only five or six stiff setae.

Appendages. The *antennule* (fig. 76, *4*) is short, with a flagellum reduced to four joints, the terminal two elongate; the *antenna* shows the first two peduncular joints short and wide, the following three increasing steadily in length and becoming

increasingly slender; the flagellum of twenty joints, also, shows the distal joints slender, but not noticeably longer than the proximal. The *labrum* is distinctly asymmetrical and at its base much wider than its depth. The *mandible*, except that it appears unusually bulky, does not differ noticeably from that of related species; the third joint of the palp bears two rows of doubly pectinate setae. The *labium*, also, is normal, but the *maxillula* is unique in this sub-family in that on the hinder face of its outer endite there are *five* feebly plumed setae, all in its mesial half, while the proximal endite is narrowed and its innermost apical setospine is obviously undergoing degeneration; it is smaller than the rest and slipping down onto the mesial border; the final stage of this change is seen in the species of *Phreatoicoides*, where this setospine has been lost altogether. The *maxilla* calls for little comment, except perhaps to note that the row of biting setae behind the filtratory is represented by but nine pectinate setae.

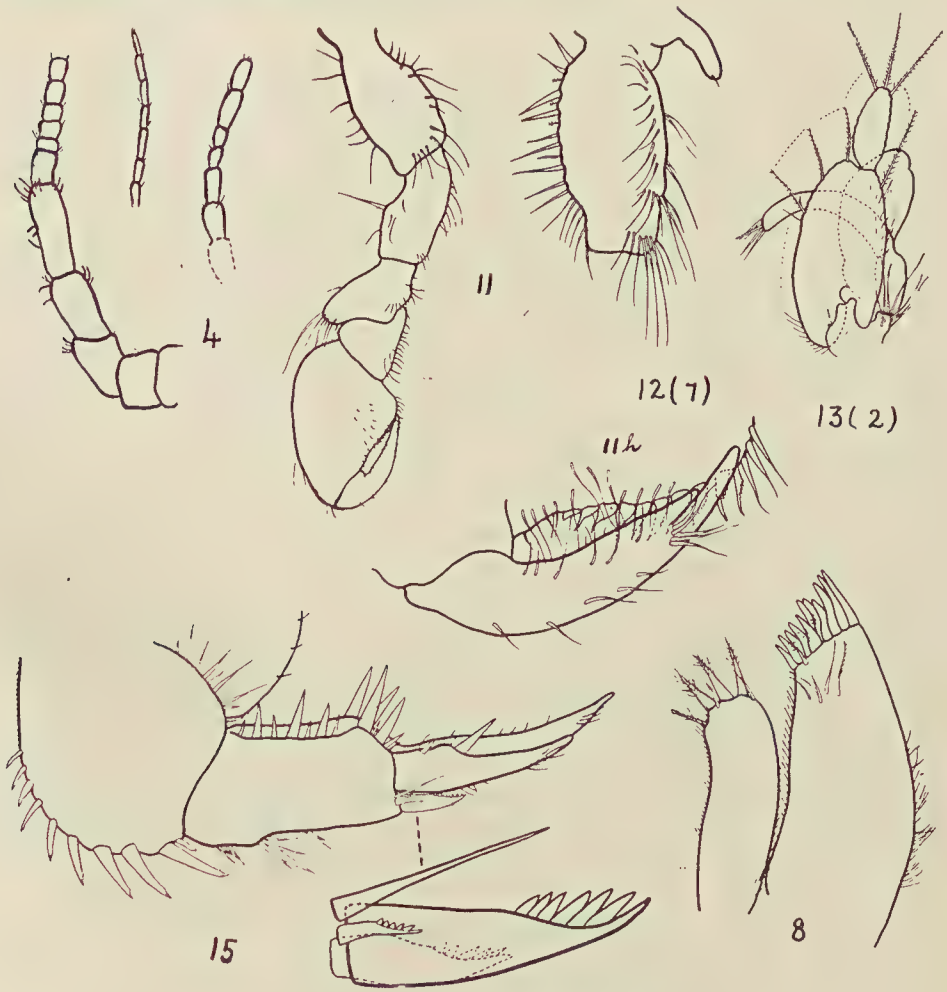


FIG. 76.—*Colubotelson setiferus*, sp. n.

The *gnathopod* (fig. 76, *11*) is rather unusually setose, the propod robust, the palm concave distally, becoming convex where it passes into the hinder border, and is unusual in that the denticulated spines are reduced to five, followed by four or five simple teeth. The setal armature of the remaining *peraeopods* is quite noticeable, and the small ciliate (sensory) setae seen on the basis of most Phreatoicid peraeopods are here peculiarly abundant. Thus on the fourth peraeopod there are at least five on the anterior border of the basis and there is one on the anterior end of the propod; this joint (in the male) has a distinct palm defined by two spines for the reception of a stout, strongly curved dactyl. It is of interest, as a detail confirming the torsion that the peraeopods have undergone, that in the hinder group these sensory setae are found on the posterior border of the basis and others occur at the posterior extremity of carpus and propod. The bases in these limbs are little expanded, there being but a quite narrow plate even on the seventh leg (fig. 76, *12(7)*). The male appendage is short, with a small terminal seta.

The *pleopods* call for little comment; it is perhaps indicative of the relative recency of the acquirement of a semi-subterranean habit that the endopodites are well developed and the exopodites still heavily setose with abundant plumose setae and a secondary fringe of simple setae. The first pleopod has both lamellae narrow; in the second (in the male) the endopodite and penial stylet are both long, the latter bearing terminally no fewer than five stiff spine-setae (fig. 76, *13(2)*).

The *uropod* (fig. 76, *15*) is of only moderate length and is comparatively stout. In the peduncle, the greatest depth is more than half of the length; the inner upper border is raised slightly, and bears but the two usual stout spines distally; the outer border nearly equals the height of the inner and bears a rank of spines, of which two are particularly strong. The inner ramus is sub-equal in length to the peduncle and, except for a few setae, appears unarmed; the outer ramus is three-fourths of the length of the inner and bears a quite stout spine at its mid-length Beneath the rami are two toothed spines, one being strong and having a length equal to one-third of that of the outer ramus.

Size. 11 mm. (male).

Colour. In spirit, a pale cream tint.

Occurrence. The two or three specimens examined were found at (or near) Scottsdale in the north-east corner of Tasmania, in a wooden pipe-line leading from the local reservoir. These were supposed (obviously erroneously) to be responsible for considerable damage (to the extent of perforation) of the pipe-line. When examined, there was found in the same tube three or four specimens of *Hyperoedesipus*, in no discoverable detail differing from the Western Australian species *plumosus*. It is scarcely credible that these were other than an accidental, though quite inexplicable, inclusion of local material after the receipt of the Tasmanian specimens. No more material could be made available and the nature of the creature responsible for the damage to the pipe remains an unsolved problem.

Metaphreatoicus, gen. n.

Telsonic process sharply upturned, abruptly truncated, shorter than wide; armed terminally with three pairs of stout spines.

Genotype. *Metaphreatoicus australis* (Chilton).

Metaphreatoicus australis (Chilton)

(Fig 77)

Chilton, 1891, pp. 149-171, pl. 22-26 *(Phreatoicus australis)*; 1894, p. 200; 1918, p. 381, fig. 13, *a.b.c.*
Spencer and Hall, 1897, pp. 12-21 *(Phreatoicus australis).*
nec. Smith, G., 1909, p. 72, pl. 12, figs 1-4 and 9 *(Phreatoicus australis).*
Barnard, K., 1914, p. 231; *nec.* 1927, pp. 159, 160 *(Phreaticous australis).*
Nicholls and Milner, 1923, pp. 24 and 34 *(Phreatoicus australis)*
Glauert, L., 1924, p. 50 *(Phreatoicus australis).*
Nicholls, G. E., 1926, p. 185 *(Phreatoicus australis).*
Sheppard, E. M., 1927, pp. 81 and 108 *(Phreatoicus australis).*

Body sub-cylindrical, fusiform, tapering from the third peraeon segment; surface smooth, scarcely wrinkled, with a few fine setae in scattered tufts on the peraeon; in the pleon a fur-like covering of setules interspersed with sparse, longish setae; the length in the male barely six times the width, and the depth (in mid-peraeon) scarcely two-thirds of the width.[1] The *head* has a moderately deep anterior emargination; it is shallow in front, but slopes upwardly from the well-developed, sub-ocular incisure, to attain a much greater depth posteriorly; the genal groove is well defined; the deep cervical groove which rises from the posterior border of the head is incomplete above and does not, as stated by Chilton, 'run across the dorsal surface'; the ventro-lateral border is nearly horizontal, but dips steeply, behind the short mandibular articulation, to include a deep post-mandibular region, from which arises a vestigial posterior process; the pre-mandibular region is relatively long and the mandible accordingly lies far back. The eyes are variable; small, round, or rounded-oval with longer axis obliquely vertical, more prominent than is suggested by Chilton's figure, with few ommatidia (about twenty, according to Chilton).

Peraeon. The first segment, which is free from the head, is short, moderately expanded ventrally, with anterior and posterior borders both concave; the third and fourth segments widest and sub-equal; the second and fifth shorter; the sixth and seventh progressively decreasing in length and increasing in depth. The postero-ventral corners of the second, third, and fourth segments are smoothly rounded and fringed with setae; on the fifth and sixth segments these corners bear but a few setae, while upon the seventh, in which setae in this region were not seen, there was a well-developed sub-marginal rank of setae stiffly outstanding from the hinder border of the segment.

All the coxae are distinct, but it is difficult to be sure that those of the second, third, and fourth are really freely movable as Sheppard states (1927, p. 93, 'the last six pairs'). In the specimens examined (which have been in preserving fluid for forty years) the chitin is quite limp and flexible, but the actual joints seem obsolete. In the female it is possible that these joints had some degree of mobility.

In the *pleon*, the first segment is distinctly shorter than the seventh peraeon segment, the succeeding segments progressively increasing in length, the lower borders rounded and fringed with long, flexible setae, which are continued some way up the posterior border, where they stand stiffly erect, and are thus liable to be overlooked; between them is a close edging of setules which, traced onto the free surface, pass into the fringes of scale-like areas which cover the body. The fifth segment, as Chilton has noted, has the junction of pleuron with tergum marked

(1) The depth is stated by Chilton (1891, p. 153), to be *about equal* to the width; if that were so, the length of the specimen figured, which is moderately relaxed, would be approximately ten times the width—a vermiform condition which is not found in this genus, but is most nearly approached in *setiferus.*

by a distinct depression; as figured by Chilton (1893, pl. 23, fig. 1), it is almost as long as the tailpiece, and the hinder margins of pleuron and tergum meet in a wide angle.

The anterior border of the pleuron of the second to fifth segments normally underlies the posterior border of the pleuron of the preceding segment for a distance varying from one-fifth to one-third of the full width of the pleuron. The extent of the overlap is clearly indicated by a line parallel to the anterior edge of each pleuron, this line, under high magnification, being set with a fine fringe of setules, giving the effect of striation. The actual anterior margin of these pleura is armed with widely-spaced, stiff, slender setae, projecting forwardly in the plane of the pleuron, whereas those on its hinder margin may project at a sharp angle from the surface. Near the dorsal end of the free posterior border there is a dense fringe of short, simple setae, best developed on the fifth segment.

The *tailpiece*, slightly longer than the fifth pleon segment, is sharply upturned in a telsonic projection which is short (wider than long) and abruptly truncated, its apex armed with six short, stout spines and several setae; the median pair of spines are occasionally rather more slender than the outer pairs. Ventral to the apex, the telsonic pleura are sharply produced posteriorly, the margin set with two spines and setae (or spinules), these latter somewhat variable in number and arrangement; there are usually two spines sub-marginally. Running antero-dorsally from the insertion of the uropod is a long, well-defined ridge, from which spring twelve to fifteen stiffly upstanding setae. It marks, apparently, the ventral border of the telsonic pleuron. Dorsally to this ridge is an interrupted parallel row of eight or more setae ending in the two sub-marginal spines already mentioned.

The antero-ventral margin of the tailpiece (the sixth pleuron) bears a close-set fringe of nine to eleven curved spines, spaced fairly evenly, and increasing in size progressively from before backwards. The end of each of these, except the hindmost, is obliquely hollowed and, in this part, pectinate. The hindmost spine is stouter than those preceding and is generally, but not invariably, simple; it is flanked by a small series of three or four short and slender spinules which are digitate terminally. Chilton, describing this region, records fifteen or sixteen spines, and in his figure (1891, pl. 25, fig. 6) represents seventeen, all apparently alike. This was presumably the condition in the specimen examined,[1] perhaps an unusually large example, but, even so, it is surprising to find so considerable a variation.

The appendages have, fortunately, been described by Chilton in very considerable detail, and comparison with other material has confirmed in almost every case these descriptions; there will be, therefore, little need here to do more than mention some points to which attention was not called.

The *antennule*, in position, reaches nearly to the end of the peduncle of the antenna, its flagellum being stated to have from five to seven joints, of which the penultimate and ante-penultimate joints are swollen; the last joint is usually minute and knob-like; there are olfactory cylinders on at least the distal three or four.

The *antennae* are short, about one-third the length of the body, the peduncle unusual in that the third and fourth joints are short and sub-equal (the third perhaps a little the longer), the fifth one-third longer than the fourth; the

[1] Chilton's original material was obtained on Mt. Kosciusko, at Piper's Creek (6000 ft. altitude). The specimens examined by the writer were determined by Chilton as *australis*, but came from Thomson's Flat at 5700 ft., also on Kosciusko. The several small discrepancies observed may be explained by this fact.

flagellum has from seventeen to twenty-two joints, and is considerably longer than the peduncle, the more distal joints becoming increasingly longer and more slender.

Chilton describes the *upper lip* as long and strong, regularly rounded distally, the centre slightly produced. Actually it is somewhat asymmetrical, though perhaps less noticeably so than in species of other genera.

There is little to add to the account of the *mandibles*; the setae on the third joint of the palp are disposed in a double row, as stated by Chilton, but those in one row are coarsely denticulate, and in the other very finely pectinate; the fulcral process of the mandible is very slightly developed.

In the *labium*, apparently the setal fringe consists in this species wholly of densely clustered, simple setae.

On the *maxillula* Chilton has recorded the occurrence of a couple of plumose setae on the posterior face of the outer endite, a feature which, though of quite general occurrence in this sub-order, has been generally overlooked; there is also one, nearly mesial, setospine on the apex of the joint among the terminal spines. Upon the summit of the inner endite there are the usual two slender, simple spines, but none of the specimens examined shows more than four setospines. Chilton records 'four or five'.

In the *maxilla*, that author has described the row of filtratory setae upon the mesial face of the inner endite as continuing for a short distance on to the (anterior) surface of this endite, a condition which is usual for the majority of Phreatoicids; it is of interest, therefore, that in one specimen examined, this fringe actually ended upon the mesial border. Lateral to the distal end of this row of filtratory setae, and situate on the anterior face of the endite at a point about one-third of the width of the endite from its inner border, is a stout spine. It is of common occurrence in this sub-order and it has been interpreted (Part I, p. 15) as the vestige of the series of spines so well developed upon the anterior face of this endite in *Mysis oculata*. It seems unusual, however, in that in this species it is finely pectinate. Running parallel to the filtratory setae on the anterior face is a bushy row of simple setae; on the posterior edge of the mesial face is the usual row of biting setae, about fifteen in number, rather unusually stout and spiniform. The posterior face of the endite is, in its distal part at least, clothed with simple setae.

Slightly behind the maxillae, in the middle line, is a small and flimsy *median process*, almost semi-circular in shape.

An error, obviously typographical, in the original account of the *maxilliped*, makes the endite of the basis project slightly beyond the inner end of the ischium—it should, of course, be *merus*, as is seen by reference to the figure (1891, pl. 23, fig. 4). The epipodite, which is quite distinctive in its shape and in that its outer margin is crenate, has a sparse fringe of eight short, curved setae, springing from the deeper crenations. Within the inner aspect of its mesial border is a thick fringe of setae. Upon the dorsal border of the endite, and restricted to its distal half, is a rank of nine or ten brush setae; these change somewhat in character near the free end, having the cilia restricted to the distal surface of the setae, which become shorter and apically denticulate or finely pectinate. Proximally to these brush setae the dorsal border is bare of setae for some distance, until near its base there is a dense tuft of simple setae.

The account of the remaining thoracic appendages calls for little amplification. In the *gnathopod*, it should be noted that the palm is armed with eight curved

spines, sub-triangular in outline, with the outer (posterior) edge coarsely denticulate[1] basally, but drawn out into a fine terminal thread. The dactyl has, in addition to the apical cluster of setae, two or three smaller tufts projecting from its anterior surface. The fourth peraeopod in the male has a quite rudimentary palm on the propod defined by three stout spines and some spinules (fig. 77, *12(4)*). The hinder borders of the peraeopods, particularly of the fifth, sixth, and seventh, are armed with setae which are in most cases almost stout enough to be described as spines. The male appendage in specimens from the type locality is generally heavily pigmented.

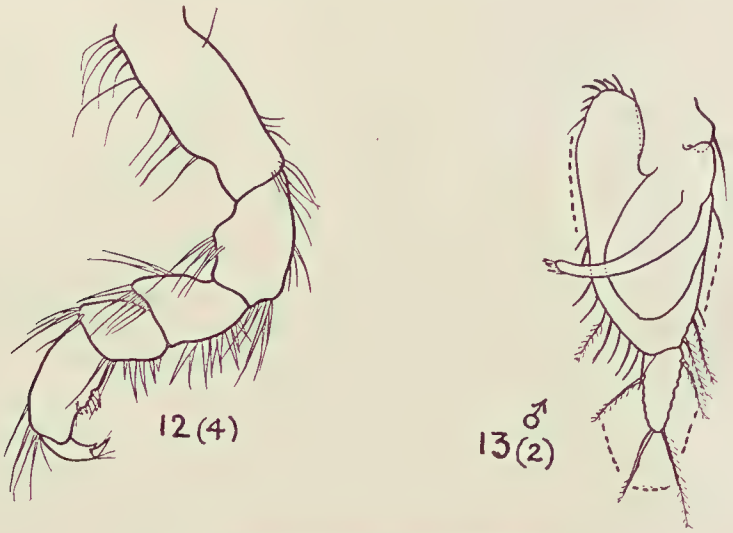


FIG. 77.—*Metaphreatoicus australis* (Chilton).

The pleopods are fully described by Chilton; the emargination of the apices of the endopodite is apparently a constant feature; it occurs in many species of this genus and *Colubotelson.*

In the second pleopod of the male (fig. 77, *13(2♂)*) the penial stylet is armed apically with four stiff spine-setae.

The uropods are stout, the depth of the peduncle being equal to half its length; the inner, upper border slightly raised and bearing two stout spines apically; the outer margin armed with five to seven strong spines. The rami are strong, the inner almost as long as the peduncle, the outer slightly shorter; both bear scattered setae, with a sub-terminal circlet, and each has one stout spine at about half its length. Beneath the insertion of the rami is one stout, curved spine, apically denticulate. In some cases there is a slender, simple spine flanking the toothed spine.

Habitat. Mt. Kosciusko. Piper's Creek (6000 ft.) and Thomson's Flat (5700 ft.).

Colour. In spirit, light brown with marbled dark-brown markings over much of the surface.

Size. About 13 mm.

---

[1] Sayce states that these are all simple!

Metaphreatoicus australis lacustris, sub-sp. n.

In many minor features these specimens from Blue Lake seem to differ from those taken from the Plateau on Kosciusko.

The *eye* seems to have fewer (nineteen to twenty-three) ommatidia.

The *antennule* is variable, in some specimens reaching only to the beginning of the fifth joint of the antenna; there are usually five or six joints in the flagellum; the swelling of the terminal joint is not simply a development of the chitin, as stated for *australis*.

The *antenna* shows difference in proportions of the joints of the peduncle.

The palp of the *mandible* lacks setae from the proximal end of the third joint. (Those figured by Chilton are on the distal end of the second joint.)

The first *maxilla* normally resembles that of typical *australis*, with four seto-spines on the inner endite, but in one specimen the inner endite is broad and bears *nine* setospines!

Setae are present on the coxa of the *gnathopod* and the second *peraeopod*—Chilton says that in *australis* setae are absent from the coxa of the first four peraeon appendages. The basis of the gnathopod is rounded; that of the fourth peraeopod is rounded, but an expanded plate springs from its anterior border. There is a fur of fine setules on the fifth and sixth joints of the seventh peraeopod, and the male appendage is unpigmented.

There is a difference in the armature of the sixth pleon pleura; the two hindmost spines are generally not pectinate and the total number may be as low as eight; the digitate spinules two or three only. The ridge above the insertion of the uropod, and marking the ventral border of the telsonic pleura, may bear from six to eight flexible setae. The truncated telson tends to be slightly longer and the apical spines are disposed differently, four being terminal, the median pair sub-terminal. The uropods seem to bear fewer spines on the dorsal borders of the peduncle.

This material was collected by Hedley from the Blue Lake, some miles from Kosciusko. The specimens apparently reach a slightly greater size, one male measuring 15 mm.

Metaphreatoicus magistri, sp. n.

(Figs 78 and 80, *l*)

This species seems to come near to *M. australis*.

The *head* is as broad as long and, in profile, appears to rise more steeply than figured for *australis* (Chilton, 1891, pl. 23, fig. 1). The eyes are larger and more prominent than in any other member of this sub-family, so that they appear in the profile of the head. There is a narrow sub-ocular incisure; the cervical groove is strongly developed, but is not complete dorsally. The post-mandibular region is rather more evident, and there is a small posterior process.

The *antennule* (fig. 78, *4*) extends beyond the end of the peduncle of the antenna and has seven joints[1] in the flagellum, the last not merely knob-like. The *antenna* is slightly longer, relatively, with about nineteen flagellar joints.

In the *peraeon* the postero-ventral corners of the segments are rounded, and in the second, third, and fourth these are fringed with setae, in this agreeing with *australis*. In the fifth and sixth segments there are fewer setae in this region; in the seventh, setae were not found here, but, instead, there is a conspicuous rank of setae along the hinder border of the segment.

(1) Only five shown in specimen figured.

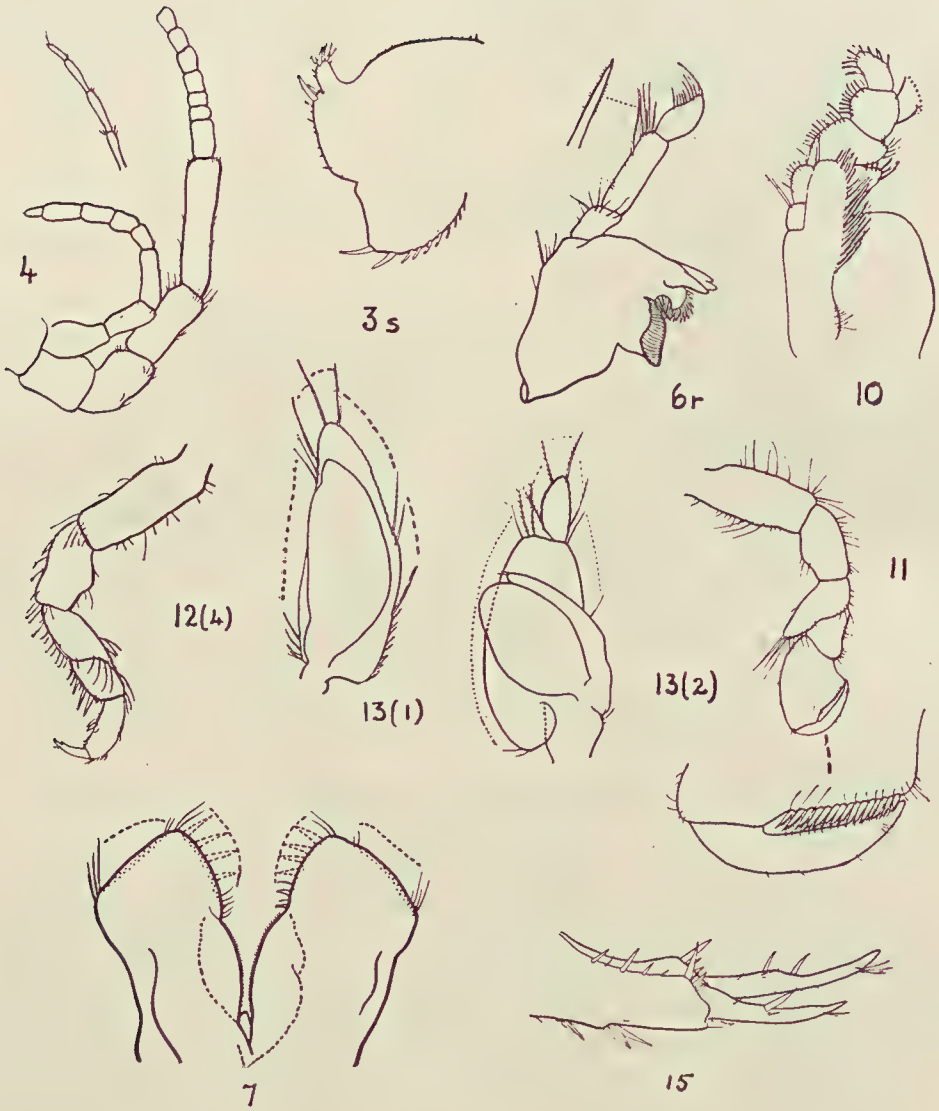


FIG. 78.—*Metaphreatoicus magistri*, sp. n.

The palm of the *gnathopod* is straight (♀) and armed with no fewer than sixteen denticulate spines; in *australis* the palm (♂) is noticeably convex.

In the hinder peraeopods the proportions of the bases differ, the setal armature is less developed and the limb appears relatively longer.

In the *tailpiece*, too (fig. 78, *3s*), this species, while distinctive, nevertheless shows affinities with *australis*.

The telsonic projection (fig. 80, *l*) is short (much wider than long), its hinder border evenly rounded with four short, equidistant spines, with a dozen or more interspersed setae; dorsally, nearer the base of the projection and slightly sub-marginal, there is a third pair of spines, smaller than the others.

The telsonic pleuron has a slightly sinuous margin and bears at its dorsal end one stout and two slighter spines, while sub-marginally is another stout spine; below this there are four or five fringing spinules and six or more setae. The ventral suture of the sixth and telsonic pleura is marked by a long ridge set with but few (four to five) stiff setae.

The antero-ventral border of the tailpiece agrees closely with that of *australis*, there being eleven fringing spines, the hindmost two stouter, and all are toothed apically. There are three posterior digitate spinules.

The *uropods* (fig. 78, *15*) are relatively longer and more slender, the dorsal border of the peduncle less spinose, the ventral edge with three tufts of setae, each with one spine. The rami are slender, the inner sub-equal in length to the peduncle, and both with more feeble armature of spines and setae.

Size. Largest male 15 mm.

Colour. Practically indistinguishable from *M. australis*.

Occurrence. Adventure Bay, Bruni Island, Tasmania. Specimens were first taken by G. M. Smith, in 1908/9, and later by the writer (28/1/28). The locality is of interest, since it lies practically at sea level; the ditch draining a small swamp, flows very sluggishly across the sandspit that joints the northern and southern parts of the island, and empties into Adventure Bay. The name proposed for this species is intended to commemorate the association of Captain Cook with the locality, the bay being named for one of his ships, the *Adventure*.

Metaphreatoicus affinis, sp. n.

(Figs 79 and 80, *m*)

This is a quite distinct form which seems to show resemblance to several different species.

The *body* is irregularly wrinkled and the exoskeleton over the body generally is excavated into numerous large ovoid or elliptical pits. The head of the male, in profile, appears almost a quadrant of a circle; it is short, about as long as the second peraeon segment; in the female, the frontal slope is more oblique. The eye is small, rounded-oval in shape; sub-ocular incisure well developed, cervical groove rising from the hinder border of the head. In the peraeon the first segment is of moderate length, well expanded ventrally, particularly in the female; the four following segments about as long as deep; fifth and sixth, though shorter, are still relatively long; the seventh, longer than the first, has depth twice its length. In all but the first, the antero-ventral corner of the tergum is produced downwardly in front of the related coxa.

The first three pleon segments are sub-equal in length, but increase progressively in depth, the first being quite appreciably longer than the last peraeon segment; the fourth is rather longer and the fifth half as long again as the fourth, and both are deeper than the third; the pleura in these hinder segments are nearly twice as deep as the related segments and in the fifth meets its segment at a sharp angle; all carry a heavy fringe of long setae.

The *tailpiece* (fig. 79, *3*) is slightly longer than the fifth segment, its dorsal surface, in profile, little convex, but dipping steeply into a concavity in front of the tip-tilted telsonic process. Seen in dorsal view, this projection appears sub-triangular in shape (approaching that found in *Crenoicus* spp.), its apex truncated or rounded, and bearing four stout, apical spines, set in a brush of short, stiff setae, twenty or more in number; laterally at the base of the projection are two rather more slender spines. Its postero-ventral aspect shows a comparatively broad, flattened, post-anal surface, reminiscent of the condition of *brevicaudatus*. Beneath the projection, the telsonic pleuron is very pronounced, its dorsal border straight, and springing, as in *australis*, from the tailpiece at a sharp angle, but armed with three stout spines, the hinder border with four or five setules; its junction with the sixth pleon is marked by a short ridge with two, or at most three, short, stiff setae.

The pleuron of the sixth pleon segment resembles that of *thomsoni*, armed with eight curved and toothed spines, increasing in length and stoutness as they are traced posteriorly; the upper anterior border of this segment is closely fringed with setules.

Appendages. The *antennule* (fig. 79, *4*) is ten-jointed, but relatively short, reaching barely to the mid-length of the last peduncular joint of the antenna. The three joints of the peduncle are sub-equal in length, and are followed by the seven-jointed flagellum, the terminal four joints bearing olfactory cylinders. The *antenna* (fig. 79, *4*) is long, with a flagellum of about thirty joints. In the peduncle, the first, second, and third joints are of nearly equal length, but the third is more slender, the fourth rather longer, the fifth equalling the combined length of the second and third and longer than the first four joints of the flagellum.

The asymmetry of the *labrum* is not very marked, and (including the epistome) it is as broad as deep.

The left *mandible* has the usual four teeth on the principal cutting edge, three on the *lacinia mobilis*; in both, the palp has a long second joint, with a dense setal fringe along its length; the third joint appears quite short and bears a double rank of pectinate setae (fig. 79, *6r*).

The *lower lip* has quite moderately well-developed inner lobes. The *maxillula* is normal, with four setospines and two simple spines on the apex of the inner endite, but these latter are rather unusually feeble; ten spine-teeth and one short setospine constitute the armature of the outer endite.

The *maxilla* (fig. 79, *9*) is quite unusual in that there may be either three or four spines (singly-pectinate) on the anterior face of the inner endite. In no other Phreatoicid[1] has more than one of these spines been observed, although, as noted earlier (Part I, p. 15, fig. 5A, *a.s.*) they are better represented in Mysids.

The *maxilliped* (fig. 79, *10*) has a long and rather narrow epipodite, its outer border bearing a dozen or so setae, rather longer than is usual on this structure.

[1] In the Amphisopid, *Eophreatoicus kershawi*, there is normally a group of three spines in this position.

FIG. 79.—*Metaphreatoicus affinis*, sp. n.

The endite is narrow and relatively rather short, with eight to ten brush setae; coupling spines, two or three in number, are stout and little curved; the joints of the palp differ somewhat in shape from those of nearly related species.

In the male, the *gnathopod* is exceptionally setose (fig. 79, *11*); the merus is short and much produced anteriorly, the propod very convex anteriorly; its hinder border is modified into a short, convexo-concave palm, six or seven denticulated spines being followed by about five short, close-set conical teeth, an arrangement closely paralleling that of *intermedius*; the free posterior border of the propod is relatively long, about two-thirds of the length of the palm. The fourth peraeopod is setose, the basis long, ischium little more than half the length of the basis, propod stout with concave palm, defined by three spines; dactyl short and stout.

In the hinder group of *peraeopods*, the basis of the fifth and sixth are less expanded, relatively, than those of *australis*; the seventh (fig. 79, *12(7)*) has a quite distinct expansion on this joint and the leg as a whole is setose with spines on ischium and merus; the propod and dactyl are long.

In the *pleopods*, the endopodites are well developed; in the first, the sympodite has a number of setae on its lateral border; the exopodite is setose, some of these setae arising from the posterior face, and there is a sub-marginal series of long setae. In the second of the male (fig. 79, *13(2)*) the endopodite is longer than the proximal joint of the exopodite; the penial stylet is quite unusual in that it bears a series of about seven stiff, terminal setae, these passing into a mesial fringe of shorter setae. Such a well-developed armature is not known in any other species of *Metaphreatoicus*, although most closely approached in *M. australis* (Chilton). It agrees, however, with the condition in *Onchotelson brevicaudatus*, and is approached in *Uramphisopus pearsoni* and some species of *Notamphisopus*. It is surpassed only by *Eophreatoicus kershawi*.

The *uropod* is slender, the two rami practically sub-equal, and the inner (slightly the longer) is as long as the peduncle; each ramus is armed with one spine at its mid-length. The peduncle bears the usual two stout spines distally on its inner border, and on the outer border is a series of spines, the most distal being unusually stout and digitate. Beneath the insertion of the rami are two stout, toothed spines.

Size. The largest specimen (♂) measured 13 mm.

Colour. In spirit, a light brown.

Occurrence. A few specimens were collected (13/3/34) by Miss D. Spargo, on Wombat Moor, in South-Central Tasmania.

In addition to the species of *Paraphreatoicus* and *Metaphreatoicus* described in the present paper, a few specimens from other localities have been examined. These have been either too few or immature (in one case fragmentary) to permit of a satisfactory description. A list of these is attached.

1. From Lake Sorell a few specimens were taken, generally resembling *intermedius*. As Geoffrey Smith notes, no Phreatoicids were found in the water of that lake in 1907/8 and, as the writer similarly failed to find Phreatoicids there twenty years later, it is possible that specimens from the Great Lake have since been introduced.

2. A single specimen from Table Mountain.

3. Some fragments, taken in shore collecting (marine material) at Wynyard, in North-West Tasmania, were seen in the collection of the South Australian Museum. They are unidentifiable and a visit made to this locality in February,

1939, failed to discover the presence of Phreatoicids in nearby fresh water, either standing or emptying into the harbour. It was, however, a period of exceptional dryness and it is probable that under more favourable conditions specimens might have been found.

Lastly, Geoffrey Smith records a distinct variety (unnamed) from Ben Lomond, but specimens from this locality have not been available for examination. There can be little doubt that many more Phreatoicids still remain to be discovered in Tasmania.

Supplementary Note

Family *Acanthotelsonidae* Meek and Worthen 1865.

It appears probable that the above family should be placed in the Phreatoicoidea rather than in the Syncarida, as proposed by Packard (1886). Considered originally to be closely akin to the Amphipoda, the only genus *Acanthotelson* was finally referred by those authors to the Tetradecapoda, but to no previously recognized family, presumably occupying a position intermediate to the Amphipoda and Isopoda.[1]

As in the case of *Protamphisopus*, the characters which would determine its position within the Phreatoicoidea are unfortunately not known. In the possession of an elongate spinous telsonic projection it differs from the Syncarida and is most nearly approached by the Great Lake members of the Mesacanthotelsoninae, all of which lack the *lacinia mobilis* from the right mandible.

There are, however, several characters which mark off *Acanthotelson* from all existing Phreatoicids and link it with the Syncarida. The first to be noted is the distinctness of the sixth abdominal segment from the telson. The failure to develop these as distinct regions (or their complete fusion) in Phreatoicids is obviously a change which has occurred in most Malacostraca. Only in a few as, for example, *Mysis*, is there a sixth segment which is lost only in later developmental stages. Were it not for the fact that the anal opening is accepted as marking the sternal face of the telson, it might be supposed that, in the Phreatoicinae, the whole of that terminal region had disappeared, leaving only the rounded hinder border of the sixth pleon segment with the anal opening presented posteriorly instead of ventrally; a half-way condition, perhaps persisting in *Phreatoicopsis*, in which a terminal rim seems to constitute the residue of this (seventh) telsonic area.

Secondly, the maxillipeds *seem*[2] to have been large and well developed and definitely of the Syncaridan type; therefore, it is interesting to note in this connection that this appendage reaches relatively its strongest development in *Mesacanthotelson*, the Phreatoicid which most nearly resembles *Acanthotelson*. But the second thoracic legs were clearly much larger and stronger than the succeeding thoracic appendages, a condition which is found in Phreatoicids but not in extant Syncarids.

The third character which may distinguish *Acanthotelson* from all extant Phreatoicids is the alleged two-branched condition of its antennule, a feature which is normal for Syncarida. Actually, however, Meek and Worthen's reconstruction

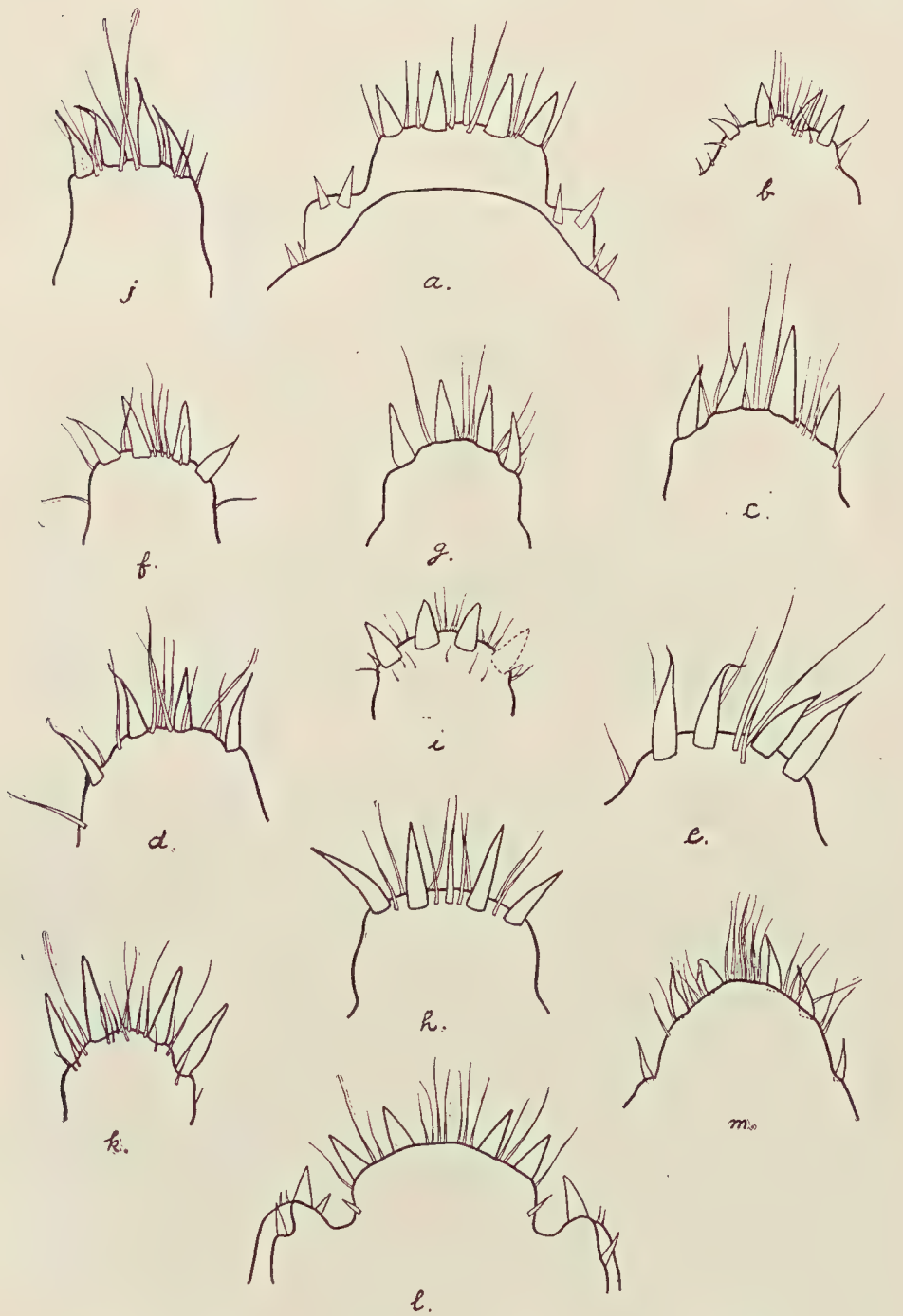
---

(1) G. Smith, 1909 (Q.J.M.S., vol. 53, p. 500), has suggested that *Acanthotelson* should be considered as a generalized Amphipod.

(2) It should be noted, however, that only in Meek and Worthen's paper (1868, p. 551, fig. B) is there a suggestion of a stout appendage anterior to the second thoracic and fig. D suggests that this appendage is really the second thoracic of the opposite side: if that is the correct interpretation, then the maxilliped of this form remains unknown but was probably not as large as it is in Syncarida.

of *A. stimpsoni* is not convincing, for it is noteworthy that the double flagellum (with both rami equal!) is apparently not represented in any specimen which is seen in dorsal view. It is true that it is shown quite convincingly as a biflagellate structure in a later figure of *A. eveni* (Meek and Worthen, 1868, p. 551, fig. D), but it is noted that this is a *diagram* made from a specimen preserved on its side, one in which the two flagella are not seen. Indeed, it seems to have been only once figured, and that in a specimen seen from the side, this showing a condition that could very well be brought about by the superposition of the base of one antennule upon that of the other. It is noteworthy that Packard does not figure it in his reconstruction.

For the rest, in most of its features *Acanthotelson* seems to resemble more closely the Phreatoicoidea than the Syncarida; the eyes were probably sessile; the antennae devoid of a scape; the peraeon has but seven recognizable segments, all sub-equal; exopodites do not appear on the peraeopods; the pleopods appear to have been biramous and lamellar, with a well developed sympodite. Cockerell (1916, p. 235) has suggested that the styliform rami of the uropods distinguish the *Acanthotelsonidae* from the other Syncarid families. Actually the single pair of uropods resemble those of Phreatoicids in that (i) they do not form part of a tail fan, (ii) the exopodite is not notched, suggesting an unequal division into two joints, as is the case in the extant Syncarida, (iii) the outer ramus is fringed with spines and setae and *is shorter than the inner*, this being an invariable feature in Phreatoicids, while the reverse is true of Syncarids, and (iv) they could well have been used (as they are in Phreatoicids) as an aid in walking. *Pleurocaris annulatus*, which is regarded by Calman as very little removed from *Acanthotelson*, shows much the same departure from the Acanthotelsonid condition as does *Onchotelson spatulatus mihi* from that of Mesacanthotelson spp.



a—searlei
b—campestris
c—hounensis
d—thomsoni
e—evansi
f—gesmithi
g—chiltoni
h—minor
i—fontinalis
j—setiferus
k—intermedius
l—magistri
m—affinis

FIG. 80.—Telsonic apices of various species of *Colubotelson* and *Metaphreatoicus*.

Pap. & Proc. Roy. Soc. Tasmania, 1943 (15th December, 1944.)

A Century of Ideas on Evolution*

By

Eric Ashby

Professor of Botany, University of Sydney

(Read 14th October, 1943)

INTRODUCTION

For an hour, let us put aside our present anxieties to consider the greatest intellectual adventure in a century of biology: namely, research on evolution. I propose to traverse very briefly the ideas about evolution which were current in 1843; the effect of the publication in 1859 of the *Origin of Species*; the views on evolution held at the time of your Jubilee in 1893; and the 'modern synthesis,' as it has been called in a recent book by Julian Huxley. I am obliged to draw most of my examples from among plants, because I cannot speak from first-hand experience of animals.

1843

The Royal Society of Tasmania was born into a very different world from our own. Lord Shaftesbury was still fighting to prevent children of five being sold as sweeps to climb chimneys, and there was still no legislation to prevent children of ten being employed in factories for as many as 69 hours a week. In 1843 Dickens published *Martin Chuzzlewit* and Carlyle published *Past and Present*. Wagner had begun to write his operas. Huxley was a medical student at Charing Cross Hospital. Darwin, his health broken at the age of 34, had just moved to the country house at Downe, in Kent, where he spent the rest of his life.

It is a mistake to suppose that the ideas of evolution and natural selection originated with Darwin; though it is a worse mistake to suppose that these ideas would have been established without the immense intellectual effort Darwin made. In 1843 biologists as a whole accepted the view that species were immutable, that each new species was the result of a special act of creation. But in the thirty years before 1843 there had been two intellectual crises in natural history, which encouraged speculation and cleared the way for fresh ideas. The first crisis was the realization that fossils were the remains of organisms, and not merely temptations hidden in the earth by Satan. Cuvier and Lamarck in France had compared the skeletons of fossil and living animals and had demonstrated that many creatures of earlier geological ages were unlike living creatures. The second crisis was the acceptance of the principle of uniformity in the geological record. Hutton

* Lecture given at the Centenary Celebrations of the Royal Society of Tasmania.

and Lyell, in Britain, had challenged the idea that the past history of the earth was a series of catastrophes; that successive strata of rocks were separated by wholesale extinctions; that each new geological age began with new creations of living things. The old notion of the earth's history as a series of catastrophies died hard. Writing at the coming of age of the *Origin of Species*, Huxley (1907) said that even in 1859 'a scheme of nature which appeared to be modelled on the likeness of a succession of rubbers at whist, at the end of each of which the players upset the table and called for a new pack, did not seem to shock anybody.'

In 1843, therefore, biologists were familiar with the fossil record, and knew that organic remains in the rocks were so different from living forms that they had to be classified as separate species, genera, and families. This did not entail belief in evolution, but it opened the door for the ideas to come in. A member of the Tasmanian Society, Mr. Jukes, wrote in *The Tasmanian Journal* (1846) that the rocks should be looked upon 'as a great series of documents' unfolding 'the wonderful story of the changes which have taken place upon the globe.' Mr. Gunn, of Launceston, communicated an article to the same journal (1846) on the fossil bones of a mastodon, found in Australia. The fossil had been sent to the famous anatomist, Professor Owen. Owen was greatly excited by this evidence of a prehistoric creature closely resembling the mastodons of Europe and America. He wrote to Australia to say 'Depend upon it, your alluvial and newer Tertiary deposits are the grave of many creatures which have not been dreamt of in our philosophy.' This same Mr. Gunn, of Launceston, has put on record in the first volume of *The Tasmanian Journal* (1842) a very interesting comment. He points out that countries whose natural boundaries are formed by mountains, seas, and deserts have floras peculiar to themselves, and yet 'by art' plants may be cultivated outside their natural boundaries of distribution.

It is not surprising that in this atmosphere there were writers who speculated that perhaps the forms of animals and plants were not fixed, but in course of time had changed from one species to another. Lamarck had declared in 1807 that all living species were descended from other species. Dr. Wells had read a paper in 1813 to the Royal Society of London, containing the same suggestion, for Man. In 1822 the Dean of Manchester, the Rev. W. Herbert (see Darwin, 1900) said that 'horticultural experiments have established, beyond the possibility of refutation, that botanical species are only a higher and more permanent form of varieties.' In 1844 Chambers, the Edinburgh publisher, brought out the *Vestiges of Creation* which preached a doctrine of the mutability of species, but it was supported by data so inaccurate that the thesis was condemned in the eyes of all scientific men.

Even natural selection was not a new idea in 1843. Indeed, Dr. Johnson, with characteristic acumen, had thrown it out during a conversation on Easter day, 60 years earlier. Listen to him: 'I believe, Sir' (said Boswell), 'a great many of the children born in London die early, but those who do live are as stout and strong people as any. Dr. Price says they must be naturally strong to get through.'

'That is system, Sir. A great traveller observes that there are no weak or deformed people among the Indians . . . he assigns the reason of this, that the hardship of their life as hunters and fishers does not allow weak or diseased children to grow up. Now, had I been an Indian, I must have died early; my eyes would not have served me to get food.'

All these suggestions, and many others, were no more than ripples upon the sea of scientific opinion. Lamarck's views were dismissed because he went beyond his data. Chambers' views were dismissed because his data were inaccurate. The observations of Wells, Herbert, Grant, and others were too trivial to upset a belief which was taken for granted, and which was consistent with the teaching of the church.

Meanwhile, Charles Darwin was accumulating a more detailed and exact knowledge of natural history than any man before him. 'In October, 1838,' he wrote (1887, vol. i): 'I happened to read for amusement Malthus on Population, and being well prepared to appreciate the struggle for existence which everywhere goes on from long continued observation of the habits of animals and plants, it at once struck me that under these circumstances favourable variations would tend to be preserved and unfavourable ones to be destroyed. The result of this would be the formation of new species. Here, then, I had at last got a theory by which to work; but I was so anxious to avoid prejudice that I determined not for some time to write the briefest sketch of it. In June, 1842, I first allowed myself the satisfaction of writing a very brief abstract of my theory in pencil in 35 pages; and this was enlarged during the summer of 1844 into one of 230 pages, which I had fairly copied out and still possess.' This abstract is in outline substantially the book published fifteen years later as the *Origin of Species*. So the year in which Queen Victoria approved the constitution of the Royal Society of Tasmania was the year in which the first draft of the theory of evolution by natural selection was written.

Darwin realized that to drive out belief in the fixity of species would need an immense body of facts. That is why he would not publish his views at once. All his contemporaries: Hooker, Owen, Lyell, the young Huxley, took the fixity of species for granted; indeed, until 1837, Darwin had taken it for granted himself. In a letter written in 1844 or '45 Darwin said (1887, vol. ii): 'In my wildest daydream I never expect more than to be able to show that there are two sides to the question of the immutability of species.' Meanwhile the obvious facts of the fossil record were merely described without being explained. The geologist Lyell wrote (Darwin 1887, vol. iii): 'I taught that as often as certain forms of animals and plants disappeared, for reasons quite intelligible to us, others took their place by virtue of a causation which was beyond our comprehension; it remained for Darwin to accumulate proof that there is no break between the incoming and the outgoing species, that they are the work of evolution and not of special creation.'

Such, in 1843, was the state of opinion about the immutability of species. The idea of evolution through natural selection had been born. Already in the mind of one man there had been a revolution. Sixteen years were to pass before the revolution broke upon the world.

1859

In 1858 a joint paper on evolution by Darwin and Wallace was read at the Linnean Society of London, and in November, 1859, an 'abstract' of Darwin's work was published under the title of the *Origin of Species*. The book was a best seller. The first edition was sold on the day of publication. It took the scientific world by storm: not because the ideas were entirely novel, but because for the first time they were supported by evidence; overwhelming evidence. Darwin, as Huxley said of him, was 'as greedy of cases and precedents as any constitutional lawyer.'

The basis of Darwin's theory can be expressed very simply. He sets out evidence for three facts: (*a*) that populations of organisms multiply in such a way that they should increase geometrically; (*b*) that, in spite of this, the population of any particular species in any region remains approximately constant; (*c*) that organisms belonging to the same species are variable both in structure and function. From the first two facts Darwin deduced that there must be a struggle for survival and a high mortality. From the third fact he deduced that in this struggle there is a selection of the 'fittest' organisms. Variations which confer fitness on the organism will therefore survive and be transmitted to the next generation. For certain parts of his theory Darwin could not secure adequate evidence, and he had to rely on assumptions. These assumptions were: (*a*) that some unknown mechanism caused the appearance of great numbers of small variations in a population; (*b*) that most of these variations are inherited; (*c*) that effects of the environment on an organism are not, as a rule, inherited; (*d*) that a hybrid between two varieties of a species shows a blending of the variations of its parents; (*e*) that despite this continuous blending the variability of a population is sustained. There were several weak points about Darwin's theory, which he noticed himself at the time, and did not attempt to disguise. The first is that on a theory of blending inheritance variation would not be preserved; it would disappear: and this was contrary to observation. The second difficulty was that on the theory of natural selection there would be all gradations between the new species and the old. This, too, was contrary to observation. A third difficulty was that the theory did not explain how, and at what stage, the incompatibility characteristic of many species (i.e., the inability to interbreed) arose in the separation of species. Then there were minor criticisms: how could one distinguish heritable from non-heritable variations? Was the theory consistent with the parable of the sower—was it not a fact that the greater part of mortality in nature was purely fortuitous and did not depend on fitness? How was it that some evolutionary trends, as revealed by the fossil record, seemed to have no adaptive significance at all? To some, Darwin's immense weight of data seemed inadequate to justify a theory so ambitious. His evidence was assembled largely from the experience of plant and animal breeders. The production of new varieties through selection by man was for Darwin a model of the similar, though slower, selection of well adapted types by nature. In his modesty, Darwin was prepared to admit that part of his theory was the substance of things hoped for, the evidence of things not seen.

1893

Darwin's disciples carried the implications of his theory much further than he himself ever intended. As so often happens, admirers were liable to become more embarrassing than opponents. By the time the Royal Society of Tasmania celebrated its Jubilee, in 1893, Darwinism had overcome popular prejudice and religious bigotry, and had won the confidence of almost every biologist. In 1880 Huxley, who had fought for Darwinism when it began as a heresy, had to issue a warning lest it should end as a superstition. And indeed the warning was necessary. Haeckel, in Germany, founded an uncompromising monist philosophy based on Darwin's theory. Arrogant German nationalism found a comfortable justification in the principle of survival of the fittest. Even in the narrower field of biology, Weismann claimed more for the efficacy of natural selection than the data warranted. It looked as though the *Origin of Species* had done for biology what the *Principia* had done for mathematics.

But at the time of your Jubilee, another intellectual revolution had been accomplished in the mind of one man, though it had not yet swept over the world of science. As long before as 1866 Gregor Mendel, afterwards Prälat of the Augustinian Monastery at Brünn, had published in the transactions of the local natural history society two short papers on the mode of inheritance in peas. For 44 years the immense importance of these papers was unrecognized. Suddenly, in 1900, they broke upon the world and shook the very foundations of neo-Darwinism.

The so-called Mendelian laws of inheritance seemed at first to undermine those assumptions that Darwin had to make. Darwin assumed that variation was continuous and that variations blend in inheritance: Mendel proved that variation was particulate, and that the units of variation do not blend in inheritance. Pea plants, for instance, were either tall or dwarf; all other variations in height were due merely to the environment and were not inherited. Moreover, a cross between tall and dwarf was not intermediate in size, but tall. It seemed, therefore, that selection could not work by degrees on minute variations, gradually transforming one variety into another and one species into another through many generations; for the only heritable variations were large. Biologists were in a dilemma: for the fossil record showed evolution to take place by gradual modification through millions of years; whereas this new science of genetics showed that heritable characters were particulate, and it seemed as though modification of species could occur only by big steps. Darwinism declined. In the hands of Bateson in England, Correns in Germany, de Vries in Holland, Mendelism flourished. Fifty years of Darwinism had failed to solve some of the problems of inheritance. Mendelism was solving problems every day. The geneticist succeeded the morphologist in the front line of research. For the time being the problems of evolution were shelved.

We will not pause to follow the fantastic way in which genetics, aided by cytology, brought light into the mysteries of inheritance. We next have to consider how, since the last war, Darwinism has emerged from eclipse. The technique of genetics is now being applied to the study of evolution. The results of this work have been promising beyond the wildest optimism of biologists twenty years ago: I propose to discuss with you some of these results.

A Digression on Genetics

As a preliminary to this, let us digress to review the present state of our knowledge of the laws of inheritance. We know that the units out of which plants and animals are built are cells, and that each cell arises from a pre-existing cell by division. When this division occurs the nucleus undergoes regular changes. It becomes visibly organised into chromosomes. Apart from certain exceptions, these are constant in number and in shape for each species, and it can be recognised that they are in pairs. Each type of chromosome has a similar partner. Thus, in the fruit fly there are four pairs, in the lily 12 pairs, in *Eucalyptus gummifera* 11 pairs, in Man 24 pairs. During cell division every chromosome splits along its length, and every new cell has a complete 'double outfit' of chromosomes. When reproductive cells are about to be formed the chromosomes do not split: instead they assemble in pairs like partners in a dance. One set of chromosomes moves to one side and the partner set to the other side. Thus, in the sperms or eggs of the fruit fly there are not four pairs of chromosomes, but four chromosomes without partners; in the sperms and eggs of Man there are 24 chromosomes without partners; and in the pollen grains and eggs of lily and eucalyptus, 12 and 11

chromosomes without partners. Cells in this condition are said to be haploid. When fertilization occurs the set of chromosomes in the egg is united with a similar set of chromosomes from the sperm or pollen grain. Each chromosome regains a partner. The new organism has a complete double outfit of chromosomes. It is said to be diploid.

These manœuvres of the chromosomes occur, with occasional accidents which I shall mention later, every time reproduction takes place. The chromosomes are, as it were, shuffled and dealt out again in the reproductive cells. It has now been established beyond doubt that almost all the units of inheritance lie on these chromosomes. They are called genes. They determine such characters as eye colour in fruit flies, tallness and dwarfness in tomatoes, right- and left-handedness in Man. In fact, it is possible to draw 'chromosome maps' which show the position of the genes; and in the salivary glands of some creatures, where the chromosomes are large, it is possible to see, under the microscope, the position of these genes. In the fruit fly, *Drosophila melanogaster*, it is estimated that there are some 5000 genes, and we think their size to be about that of 10 protein molecules, 10^{-8} to 10^{-5} cubic microns (Gulick 1938).

Since the common animal or plant carries a double outfit of chromosomes, it will have two genes for every character. These may be the same or they may be different. If they are different, if, for instance, a fruit fly carries a gene on one chromosome for white eye and a gene on the partner chromosome for red eye, we do not find that the animal strikes a compromise between these two potentialities. It has completely red eyes. In other words, the potentiality for making red eyes masks the potentiality for making white eyes. We say the gene for red eye is dominant and the gene for white eye is recessive. All wild animals and plants carry thousands of recessive genes which do not exert a visible effect on development. But if, as a result of crossing, two recessive genes are brought together, then the recessive character appears. For instance, real albinos, with no pigment in the hair at all, are rare among human beings: approximately one occurs among 10,000 people. There are probably about 25 of them in the whole of Tasmania. But two persons in 100 carry the gene for albinism as a recessive. It may be transmitted as a recessive through generations and it will not be recognised; but if a sperm and an egg, both carrying the gene for albinism, unite, then an albino is born.

These genes are stable over many generations. But occasionally they change suddenly, often with no apparent cause. Thus the genes controlling leaf shape in *Primula sinensis* have changed to produce forms known as maple, tongue, crimp, oak, fern, and many others (fig. 1). These changes are called gene mutations. Once the mutation has occurred it is fixed for good. Mutations are rare: in the fruit fly, for instance, they occur about once in 100,000 individuals.

It used to be thought that every character in the organism was determined solely by its peculiar controlling gene, but we know now that this is an oversimplification. For instance, the recessive gene for crimp leaf, if it is present in two doses, has the major effect on leaf shape, but we think it likely that all the other genes affect shape to some degree. The same mutation for crimp leaf may therefore have a profound effect in one plant, because it is emphasised by the other genes present; in another plant it may have a small effect because it is suppressed by the other genes present: leaves may be 'very crimped' or 'not so crimped.' This discovery has such an important bearing on the theory of evolution that I want to emphasise it by means of an analogy. Some of you are bridge-players. You know that there is no absolute value to be assigned to, let us say, the knave

of hearts. Its effect depends on the other cards in the hand. It might determine the game. It might have no influence at all. The effect of a single card on the outcome of the game is modified by the other cards in the hand. This roughly illustrates our modern views about the effects of genes. Add to the analogy that there are some 5000 to 20,000 cards in the hand, and that from time to time cards 'mutate' into entirely new cards never seen before and which you are allowed to play, and you have some inkling of the possibilities of Mendelian inheritance.

FIG. 1.—Leaves of *Primula sinensis* showing effects of single genes on shape. (after de Winton and Haldane.)

Here, then, is the first missing piece of evidence for Darwin's theory. Darwin made no suggestions about the causes of variation: he confined his discussion to the consequences of variation. We now know that variation is due to recombinations of genes following crossing, and that variation among genes is due to occasional gene mutations. At first it seemed as though this evidence was inconsistent with Darwinism, because it led to the conclusion that evolution is essentially discontinuous. The 'all-or-none' reaction to genes by the organism led to the assumption that species differences, which depend on genes, should be sharp and unmistakeable; and this assumption was inconsistent with the fossil record. This apparent inconsistency contributed to the eclipse of Darwinism: but it has been resolved by recent research. For we now know that the effect of a mutation is buffered by all the other genes present, and we may therefore expect to find under some circumstances a graduation of types from mutant to normal.

The second important piece of evidence missing from Darwin's data was the machinery for producing infertility. How could a population of one species become split into two or more species which are infertile with each other? Almost invariably the genetical types within a species will interbreed. White sweet peas

cross with red sweet peas: black cats cross with tabby cats; tall tomatoes cross with dwarf tomatoes. Commonly (although not invariably) distinct species will not interbreed. How, then, can species arise from genetical types? The first evidence from genetics seemed to contradict Darwin's assumption that sterility would follow the origin of new species. This was another reason for the eclipse of Darwinism; but recent research has resolved this apparent disagreement too. For we now know that some gene mutations confer sterility in cross breeding; and that there are other sorts of mutations beside gene mutations: other sorts of accidents to the chromosomes which confer sterility. For instance, there is sometimes a breakdown in the mechanism which 'deals out' chromosomes in cell division. This results in the formation of cells with four times, six times, eight times the basic number of chromosomes. When this occurs in animals the cells die and the results of the accident are not carried into the next generation. But if it occurs in plants it gives rise to what we call polyploids. Often these polyploids have all the appearance of new species. They are fertile with one another and they are usually infertile with the plants from which they arose. It is now established that a very great number, perhaps the majority, of present-day species of plants are polyploids, with 4, 6, 8, 12 . . . complete outfits of chromosomes, or with irregular numbers of extra chromosomes. For instance, the various species of Chrysanthemums have 9, 18, 27, 36, or 45 chromosomes. The wild strawberry, *Fragaria vesca*, has 14 chromosomes; *Fragaria elatior*, the cultivated strawberry of the sixteenth century, has 42 chromosomes; the modern garden strawberry has 56 chromosomes. Dahlias have 16, 32, or 64 chromosomes, according to the species.

Choromosome accidents can take the form also of the breaking off of parts of chromosomes and their joining up to other chromosomes; or their breaking off and rejoining upside down: these are so-called translocations and inversions. At first sight translocations and inversions would seem to have little effect on the organism because the same genes are there: only their order on the chromosomes has been changed. But there is, in fact, a 'position' effect of genes. Their influence on development does depend on their place in the chromosome outfit: a phenomenon which has no analogy in a hand of cards! Furthermore, if chromosomes have been broken and rejoined in a fresh position they frequently will not pair with ordinary chromosomes on fertilization. Therefore, the new race with translocations and inversions is not fertile with the old race from which it has come. Those are two ways in which sterility between species can arise; so that we have, to-day, evidence which dispels another of the difficulties in the way of accepting Darwin's theory. It is on account of these discoveries, and others like them, that Darwinism is now reinstated and interest in evolution through natural selection is revived.

Genetics has made another, and quite different, contribution to the study of evolution. You are familiar with the way anatomists and morphologists have sought over the last century for evidence of relationship between similar types of animals: comparative anatomy has been the taking of evidence for evolution. The study of comparative genetics has confirmed the results of anatomy and morphology. By studying the genes present in related forms we obtain strongly presumptive evidence of their common ancestry. For instance, tables have been prepared (table I) which show the genes known for coat colour in rodents (Haldane quoted by Waddington, 1939). There is a similar table (table II) for genes in four species of cotton (Harland, 1936).

TABLE I

Gene	Effect	Mouse	Norway Rat	Black Rat	Deer-mouse	Cavy	Rabbit
C	Normal	+	+	+	+	+	+
c^k	Slight dilution	—	—	—	—	D	+
c^d	Marked dilution ..	—	—	—	—	D	+
c^r	No yellow	D	D	—	—	D	D
c^h	Himalayan	D	—	—	—	D	D
c^a	Albino	D	D	—	D	—	D
A^y	Yellow	D	—	—	—	—	—
A^w	Light bellied grey ..	W	+	+	+	—	+
A^z	Grey bellied grey ..	+	—	W	—	+	—
A^r	Ticked bellied grey ..	—	—	—	—	W	—
a^t	Black and tan	—	—	—	—	—	D
a	Black	D	D	D	—	D	D
E^d	Black	—	—	D	—	—	D
E^s	Black	—	—	—	—	—	D
E	Normal	+	+	+	+	+	+
e^p	Bicoloured	—	—	—	—	D	D
e	Yellow	?D	—	D	D	D	D

TABLE I.—Some homologous genes in rodents. A 'plus' indicates that the gene occurs in the normal type; 'W' that it is found in the wild races; 'D' that it is found in domesticated animals. (after Haldane.)

TABLE II

Gene	Effect	*purpurascens*	*taitense*	*tomentosum*	*Darwinii*
R^H	Red plant body	n.r.	n.r.	n.r.	n.r.
r^H	Green plant body	p.f.	p.f.	p.f.	p.f.
R^B	Red plant body	Common in West Indies form	n.r.	n.r.	n.r.
r^B	Green plant body	p.f.	p.f.	p.f.	p.f.
R^D	Red plant body	n.r.	n.r.	n.r.	Found in one type, prevalence not known
r^D	Green plant body	p.f.	p.f.	p.f.	p.f.
Y^B	Yellow corolla	Character present but probably due to another allele	n.r.	Character present but probably due to another allele	n.r.
y^B	Cream corolla	Rare	p.f.	n.r.	n.r.
Y^D	Yellow corolla	n.r.	n.r.	n.r.	p.f.
y^D	Cream corolla	Rare	p.f.	n.r.	n.r.
S^B	Petal spot	Allele present but not known whether identical with S^B or S^H	Apparently represented by another weaker allele	n.r.	Allele present, probably different from S^B or S^H
S^H	Petal spot			n.r.	
s	No petal spot	Rare	n.r.	p.f.	n.r.
P	Yellow pollen	p.f.	n.r.	p.f.	p.f.
p	Cream pollen	Rare	p.f.	n.r.	n.r.
O^H	*hirsutum* leafshape	Allele present, not certain if identical	Allele present, not certain if identical	Allele present, not certain if identical	Allele present, not certain if identical
O^O	Upland okra	Occurs rarely	n.r.	n.r.	n.r.?
O^S	Upland super-okra	n.r.	n.r.	n.r.	n.r.
O^P	Laciniated leaf *purpurascens*	Rare	n.r.	n.r.	n.r
O^D	Laciniated leaf *Darwinii*	n.r.	n.r.	n.r.	Occurs
O^B	Sea Island leafshape	n.r.	n.r.	n.r.	n.r.
C^{ha}	Green	p.f.	n.r.	p.f.	p.f.
ch^a	Chlorophyll deficient	Rare	p.f.	n.r.	n.r.
C^{hb}	Green	p.f.	p.f.	p.f.	n.r.
ch^b	Chlorophyll deficient	n.r.	n.r.	n.r.	p.f.
C^o	Contorta leaf	n.r.	n.r.	n.r.	n.r.
c^o	Normal leaf	p.f.	p.f.	p.f.	p.f.
C^R	Normal	Allele present	Allele present	Allele present	Allele present
c^R	Crinkled leaf	n.r.	n.r.	n.r.	n.r.
K^B	Khaki lint	?	n.r.	n.r.	?
K^H	Khaki lint	?	Found	n.r.	?
K^T	Khaki lint	n.r.	n.r.	p.f.	?
k	White or cream lint	p.f.	n.r.	n.r.	n.r.
G^L	Green lint	—	—	—	—
g^L	White or cream lint	p.f.	p.f.	p.f.	p.f.
V	Green leaf	p.f.	p.f.	p.f.	p.f.
v	Virescent yellow leaf	n.r.	n.r.	n.r.	n.r.
H^T	Hairy plant body	n.r.	n.r.	p.f.	?
h^T	Glabrous plant body	p.f.	p.f.	n.r.	?
H^B	Hairy plant body	n.r.	n.r.	n.r.	?
h^B	Glabrous plant body	p.f.	p.f.	p.f.	?

Note. n.r. (not recorded) indicates that the gene was not present in all types of the species which it was possible to examine. p.f., prevailing form.

TABLE II.—The distribution of genes in four species of Gossypium. (after Harland.)

The advances made in genetics since the Jubilee of your Society have entirely changed our outlook on the mechanism of evolution. Since 1893 the fact of evolution has remained unquestioned by scientific men. Ideas as to the mechanism of evolution have passed through three phases: at first a sturdy belief in natural

selection as the sole driving force; then a period of disillusionment and a discrediting of natural selection; then a period of experimental work which has illuminated the theory of natural selection. To-day, at your Centenary, we can admire a splendid building on the foundations Darwin laid. The working of natural selection has been demonstrated. The consequences of it have been worked out mathematically. The origin of variations and the causes of sterility between species have been explored.

So let us return from this digression to see where Darwinism stands to-day. I shall occupy the rest of this lecture with a summary of modern views on the origin of species. The fact that evolution has occurred we may take for granted. Lyell, Darwin, Huxley, Wallace established this beyond further discussion. We now have actual pedigrees of fossil types: horses, elephants, camels, sea urchins, ammonites, pines. Let us proceed at once to discuss first, the evidence for natural selection, and, second, the mechanisms whereby new species are formed.

1943

The Evidence for Natural Selection

Robson and Richards published in 1936 a book entitled *The Variation of Animals in Nature*. In it they examine critically the numerous examples of alleged natural selection among animals. They come to the conclusion that, even to-day, the hypothesis of natural selection is not supported by adequate data, and judgment upon it must be suspended. This conclusion is, I think, unjustifiably pessimistic; but it is interesting that, even a century after the first draft of Darwin's essay, the evidence that species originate through natural selection should still be so scrappy, and to some even unconvincing.

In my opinion there is a good deal of evidence that natural selection does operate to favour the transmission, from one generation to the next, of some genes in preference to others. I propose to describe two examples. The first is a Russian experiment by Sapegin (quoted by Haldane, 1932) to discover the fate of a mixed batch of wheat grains, harvested and sown on the same plot in successive years. In 1913 a mixture of five varieties of wheat was sown in the proportions shown in the following table (figures in percentages). The columns under 1915 and 1917 show the composition of the population in those years:—

Variety.	1913.	1915.	1917.
Durum and compactum	2·5	0	0
Milturum	5·5	9	5
Lutescens	72	31	6·5
Erythrospermum	10	19	5·5
Ferrugineum	10	41	83

There is no escape from the conclusion that in this plot the variety ferrugineum flourished at the expense of the other varieties, one of which was eliminated completely.

A second example concerns what is known as 'industrial melanism' in moths (Huxley, 1942). The moth *Boarmia repandata* is normally grey, but it has a mutation to a dark (melanic) form which is dominant to the normal form. Under some conditions the melanic forms even show a higher viability, and so they are 'fitter' in Darwin's sense of the word. In country districts the percentage of melanics remains low. In industrial districts, on the other hand, the percentage is high. This difference between town and country moths is not correlated with any difference in diet or climate, and can most easily be attributed to selection.

In the country the dark colour is conspicuous and lowers the chance of survival; in the industrial town it increases the chance of survival.

The experimental study of natural selection is complicated by the multiple effects of genes and by what we might call the capricious policy of nature as a selector. Let me enlarge on these two circumstances. A gene is usually named by some visible effect, but it may exert physiological effects far more important for the survival of the organism. For instance, mutations called 'arc' wing and 'speck' on the axilla of *Drosophila* also lower the average number of progeny hatched during a lifetime; and the mutation called 'purple' eye increases the number of progeny. An experiment by Gordon (1935) demonstrates how selection occurs in nature against an apparently harmless mutation. Gordon released 36,000 individuals of the fruit fly *Drosophila melanogaster* in a Devon orchard. *Drosophila* does not occur wild in England, so the population was quite isolated. The population consisted of 25 per cent normal flies, 25 per cent pure 'ebony' flies, and 50 per cent of flies heterozygous for ebony (i.e., carrying one recessive dose of ebony). After 120 days, when there had been five to six generations of flies, Gordon trapped samples to determine the proportion of 'ebony' in the population. He found that the frequency of the ebony gene had fallen from 50 per cent at the beginning to 11 per cent. This indicates that there must be some physiological 'unfitness' correlated with ebony colour.

The second complication is the capriciousness of nature as a selective agency. The organism is subjected, as it were, to an examination by nature for which there is no syllabus. It is therefore impossible to predict whether this or that variation may prove to be useful. I have already given you one example of this, namely, 'industrial' melanism in moths. Here are two more. There is a mutation in *Drosophila* called 'vestigial wing.' The name is self explanatory. Under ordinary conditions vestigial winged flies have a lower expectation of life than normal flies. But under conditions of starvation, or in a high wind, vestigial-winged flies live longer than normal flies. The 'policy' of natural selection is reversed (Huxley, 1942). A similar instance is cited by Engledow for wheats (1925). He compared yields from two wheats (Red Fife and Hybrid H) sown at three different distances apart. When the wheats were spaced at 2″ by 2″ Red Fife gave the greater yield. When they were spaced 2″ by 6″ the yields from the two varieties were equal. At wider spacing still, Hybrid H gave the greater yield. The trend of natural selection will, therefore, depend on the spacing between the plants.

Sometimes the capriciousness of selection leads to quite fantastic results. For instance, Vavilov has recorded the occurrence of mimicry in seeds as striking as any known among insects. In parts of India lentils are grown by the peasants. There is no standardization or distribution of seed. Each peasant keeps a batch of seed from his harvest to sow in the following season. Consequently the samples of lentil seed from different districts vary in colour and size. Before planting his seed, the peasant picks it over to remove weed seeds. Seeds easily distinguished from lentils are easily removed, but any seeds resembling lentils are hard to distinguish and would not be removed. It so happens that one of the weeds, a species of *Vicia*, has seeds not unlike lentil seeds. Now any variation in the vetch seed which makes it more closely resemble a lentil seed will tend to be preserved, because the peasant will not notice it as he sorts out his seed. Accordingly, it has come to pass that the vetch weed seed in each district closely mimics the lentil seed grown in that district; so closely that it is very difficult to distinguish the two. Another example is quoted by Salisbury (1929). The fools parsley (*Aethusa cynapium*) has dwarf strains which inhabit wheat fields.

Taller strains which appear each year are decapitated by the reaper, and so do not flower. The dwarf strains can flower in the stubble. This may be the first stage of the production of a new species, for not only genes for dwarfness, but other genes (e.g., those controlling late flowering), will be selected in this environment.

These examples, even those which illustrate the complexity of selection, are sufficient to demonstrate that the passage of genes from one generation to the next is influenced by selection. The examples do not, of course, prove that new species arise as a result of this process; but if it is established that species differences are due to gene differences, we have evidence of the part played by gene selection in the origin of species. For some hundreds of species this fact has been established. It is known, for instance, that the different species of *Phaseolus* (the bean), *Gossypium* (cotton), and *Antirrhinium* are due to gene mutations. So also are the varieties and species of the snail *Partula.*

The amount of selective advantage which a mutant gene needs in order to establish itself is very small. Fisher (1930) and Haldane (1932) have worked out that a mutation occurring only once in 100,000 individuals, and with a selective advantage of only 1 per cent (i.e., a 1 per cent higher chance of surviving to the next generation) will spread through half the population in 100 generations: that is, for *Drosophila,* in 7 to 8 years; for a wallflower, in a century; for Man, in about 3000 years.

We may not dwell longer on this subject. Since Darwin's time our ideas of the operation of natural selection have changed in one important respect. There have been two steps in the change. Darwin supposed that variations, whose origin he did not specify, were directly selected by nature. Organisms with 'fit' variations survived. The rest perished. The first step in advance of this was the discovery that Darwin's variations are due to gene mutations. It was then supposed that the mutation appeared in the race and natural selection either favoured its survival or eliminated it as unfit. To-day we have gone a step farther. We now suppose that the effect of a mutation is buffered by the rest of the outfit of genes in the organism. Natural selection does not work to preserve or eliminate single genes. Selection modifies the reaction of the whole gene outfit. If a mutation is favourable, then organisms which exaggerate it are favoured in the struggle for survival. If a mutation is harmful, then organisms which suppress it are favoured. In the terms of our analogy of cards, it is the whole hand, not the single card, which determines the game.

The verdict of 1943 is, therefore, broadly in favour of Darwin's theory. But we know, to-day, that natural selection is not the sole *deus ex machina* of evolution. In fact, no single generalization can be made about the origin of new types of organisms. All we know of the evolution of the horse is irrelevant for a study of the evolution of wheat. Our knowledge of the evolution of evening primroses throws no light on the evolution of eucalypts. In brief, as Julian Huxley has put it (1942), if Darwin had to write his book to-day he would call it the *Origins of Species.* Sometimes natural selection plays a part in these origins: sometimes it does not.

From our knowledge of genetics we are satisfied that so long as free interbreeding continues between the individuals in a population, the genes responsible for variation will be distributed through that population; there will be no splitting into fresh types which breed true. It may appear that there are fresh types, but they are only so-called ecotypes. Let me illustrate what I mean by an example. Gregor (1939) found that plants of the sea plantain (*Plantago*

maritima) on coastal mud flats look quite different from plants on rocks. But the two types interbreed freely, and these two kinds of environments select anew every year the most appropriate outfits of genes. There is no good evidence that the sea plantain will break up into new species this way, unless the mud flat type becomes isolated from the rock type, and will no longer interbreed with it.

This brings us to the core of the problem. The machinery of evolution depends on the ways in which communities become isolated. For we know that once a community is isolated, gene mutations will accumulate in it; other chromosome accidents such as polyploidy, inversion, and translocation may occur. All these cause variations on which local influences of selection may work. And the result will be new varieties, ultimately new species. In a small community, where interbreeding is limited, or where competition is not severe, not only useful adaptations but all sorts of 'useless' characters may survive in the community. Isolation is the prerequisite of evolution. Isolation alone can lead to the origin of species. Let us, therefore, review the ways in which isolation may occur.

There are four kinds of isolation, all of which prevent interbreeding and each of which gives rise to its own peculiar type of species. The four kinds are:

Isolation in time, giving rise to geological species.
Isolation in space, giving rise to geographical species.
Isolation in function, giving rise to ecological species.
Isolation in genetic mechanism, giving rise to genetic species.

Geological Species

The most extreme isolation is that which separates species of one geological age from those in another. It is possible that some fossil types, if they were still alive, might interbreed with living types. Some of the divergence between fossil and living forms is, therefore, due to their isolation in time. We have some inkling of the genetic basis of fossil characters from occasional mutations in living types. For instance, the ancestors of guinea pigs undoubtedly had five toes to their limbs. Living guinea pigs have four toes on the front feet and three on the hind feet. But Sewall Wright in Chicago (1935, fig. 2) has studied a mutation in guinea pigs which, as a heterozygote (one dose of the mutant) gives five-toed animals.

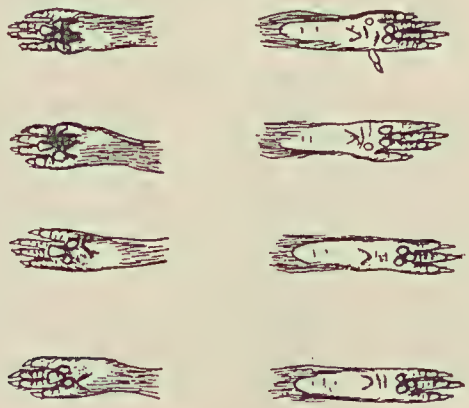


FIG. 2.—Forefeet and hind feet of normal and heterozygous guinea pigs. (after Wright.)

The most remarkable circumstance about evidence from fossils is the presence of consistent evolutionary trends. These are still among the unsolved problems of evolution, and they have given rise to a crop of philosophical theories: emergent evolution, orthogenesis, élan vital and the like. Unfortunately, there is no time to refer to them in this lecture.

Geographical Species

Let us now consider the origin of geographical species. Since the time of Lamarck it has been recognised that geographical isolation produces new species. The flora and fauna of Australia are among the striking examples of the effects of isolation. It is now pretty clear that geographical isolation alone, even without natural selection, will lead to a diversity of animals and plants. Even though the same mutation occurred in separated communities of the same species, the results would be different, for the effects of the mutation depend on the other genes present.

There are good examples of geographical species among your own eucalypts. Out of twenty-two species of *Eucalyptus* in Tasmania, ten are endemic. This is clearly not due to the endemics having a narrow climatic preference, because some of them (e.g., *Eucalyptus globulus*) are widespread under cultivation in other States.

Geographical isolation is often due to less obvious barriers than seas and mountains. The range of migration is sometimes determined by cities or by cultivated land. The distribution of the tropical fruit fly, *Drosophila hydei* is an example of this. In the U.S.A. this fly occurs only on decaying fruit, on refuse heaps and such like. It passes the winter, in greatly reduced numbers, in fruit stores, restaurants, and cellars. In the summer it multiplies and spreads in the open. But it is always a hanger-on of human communities, and there is almost complete geographical isolation between the *Drosophila* populations of different towns. Recently Spencer (1941) has compared the appearance and gene outfits of two populations: one on a refuse heap in Azusa, California, and the other in Wooster, Ohio. He examined 50,000 flies. He found that the mutations accumulated in the Ohio population were quite different from those accumulated in the Arizona population, so that one might say that here are already two geographical races, differing genetically. If these two races were mixed, any divergence between them would vanish. If they remain in isolation, and chromosome accidents accumulate in them, they may become two different species.

Ecological Species

The third kind of species-forming process is ecological. Without any geographical barriers, local differences in habitat or in behaviour may isolate animal and plant communities. This will produce in the isolated community a pocket of diversity, as it were, from which new species may emerge. Tasmanian eucalypts, which, as a group, illustrate the effects of geographical isolation, provide among themselves examples of ecological isolation. Thus, the Mt. Wellington peppermint, *E. coccifera*, is separated from the giant gum, *E. regnans*, because the two species prefer different environments. It may be that they hybridize and the hybrids may be eliminated by natural selection. Or it may be that they cannot interbreed because they flower at different times, or because they are incompatible. That remains to be discovered. The exact cause of isolation is not known, therefore: it is unlikely to be geographic; it is unlikely that pollen from one does not reach ovules of the other; it may be functional; it may be genetical.

Very slight functional differences may isolate communities and so set them on the road to diversification. Differences in season of flowering; differences in the time of day flowers open; differences in flower colour which determine the kinds of visiting insects: any of these may isolate a plant community. In the same way Dobzhansky (1937) reports that species of certain butterflies in California are isolated from each other owing to differences in the time at which the adults emerge. For instance, *Philotes sonorensis* flies from February to April and *Philotes battoides bernadino* flies in May.

It is, of course, impossible to classify many species or varieties as geographical or ecological: frequently both these kinds of isolation play a part in making a species. Among the variations whose cause cannot be assigned is the distribution of the black brush opossum in Tasmania. The story is familiar to you, for it was worked out by Dr. Pearson (1938) and published in your papers for 1937. Dr. Pearson summarized the distribution of black and grey opossums as phenocontours on a map. The black pigment is, doubtless, due to a gene mutation, possibly with modifiers (i.e., other gene mutations). It is likely that the mutation arose in Tasmania, because there are no black opossums on the mainland. The proportion of blacks falls toward the south and east, and is lower on Tasman Peninsula than on the adjoining coast. The distribution might be due to several causes, e.g., (*a*) incomplete geographical isolation within Tasmania, due to a limited range of wandering of the opossum. On this hypothesis the island was originally populated by grey opossums. A black mutation arose in the N.W. and has spread slowly along the paths of migration. This would imply that the black form had some 'additional' fitness which is selected irrespective of environment; and the proportion of black opossums in any locality would measure the time the black gene has existed in that locality; (*b*) a second cause of the distribution might be incomplete ecological isolation. On this hypothesis the distribution of the black form would depend on its having some adaptive advantage in parts of Tasmania. If this were so the proportion of black opossums in any locality would measure the selective advantage of black for that locality.

Dr. Pearson states that there is no correlation between the distribution of black forms and elevation or rainfall; though there is some evidence that for other animals melanic forms are commoner in damp, cool climates: Huxley (1942) quotes the work of Timofeeff-Ressovsky on hamsters (*Cricetus cricetus*) in support of this. I have quoted this example, however, not to try to explain it, but to illustrate the type of diversity which cannot, with confidence, be put into either of the last two categories of species.

Genetic Species

Lastly, let us review the modes of formation of genetic species. It is clear that the integrity of geographical or ecological species depends (when they first appear, at any rate) on the maintenance of geographical or ecological isolation. If the mountain barriers are overcome, if the seas are crossed, then interbreeding takes place and the species dissolve. In New Zealand, and probably to a greater extent than we realise in this country, there are among plants hybrid swarms of species. Mr. Brett has recorded excellent examples from among Tasmanian eucalypts. They are the despair of the taxonomist because they are not isolated in their breeding. But if geographical or ecological isolation lasts long enough, then changes will occur in chromosome outfits which will lead to incompatibility. Until differences in the genetic mechanism between races make interbreeding impossible, or very difficult, there is no sure stability of species.

I have already mentioned how certain mutations or accidents to the chromosomes—polyploids, inversion, translocation, and certain gene mutations, lead to incompatability. When this happens the mutants may be growing alongside the community from which they came, but they are as effectively isolated as though an ocean lay between. The researches of the last 25 years have brought to light hundreds of examples of species determined by genetic isolation. For instance, the essential difference between two species of oats (*Avena sativa* and *Avena fatua*) depends on an inversion of one chromosome which makes interbreeding very hard. The difference between *Drosophila pseudo-obscura* and *Drosophila miranda* depends upon the simultaneous presence of three sorts of chromosome changes: new and different genes, translocations, and inversions (fig. 3). Otherwise there is a similarity in the chromosomes (of number, shape, size, and gene arrangement) which is itself strong presumptive evidence that the two species originated from one another, or from a common ancestor (Waddington, 1939). A recent study by Lamprecht (1941) of the difference between *Phaseolus vulgaris* and *P. multiflorus* leads to the conclusion that the cause of species formation is gene mutation. Some of the mutations have lowered the ability of the two species to interbreed. The most striking gene-controlled differences are:

	Phaseolus vulgaris.	*P. multiflorus.*
Inflorescence at:	2-5th node	10-16th node
flower colour	no genes for red	genes for red
pods	not grooved	grooved
hilum of seed	colour not localized	colour localized

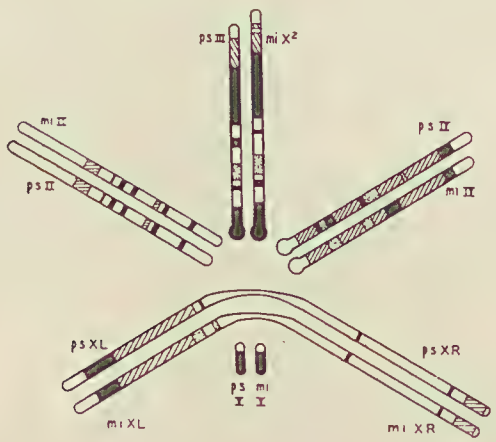


Fig. 3.—Comparative chromosome maps of *Drosophila pseudo-obscura* and *D. miranda*. Regions with the same gene arrangements are white; inverted sections, cross hatched; translocations, stippled; and sections of which homologues are not detectable in the other species, black. (Waddington from Dobzhansky.)

Another common cause of genetic isolation in flowering plants is polyploidy: the presence of 3, 4, 6 or more complete chromosome outfits. For instance, the various species of wheat fall into three groups: the so-called *Einkorn* group with 14 chromosomes (a double outfit of 7); the *Emmer* group with 28 chromosomes (a

quadruple outfit of 7); and the *Vulgare* group with 42 chromosomes (six outfits of 7). There is evidence that emmer-type and vulgare-type wheats have arisen from einkorn-type wheats, but they are sterile when crossed with einkorn wheats. When emmer and vulgare wheats are crossed, some fertile offspring are obtained: this proves their 'blood-relationship,' though the chromosomes behave irregularly.

We have abundant evidence that new species arise in nature through polyploidy. Perhaps the most striking example is the origin of rice grass, *Spartina townsendii* (Huskins, 1931). Up to a few years ago two species of *Spartina* were found on the Southern Coasts of England: *S. stricta*, a native of Britain, and *S. alternifolia*, imported from America. A few years ago a new species appeared. It was named *Spartina townsendii*. It was undoubtedly a new species, and it was more vigorous than the other two species: so much so that it was soon being used by the Dutch for reclaiming land from the sea. A study of the chromosome numbers showed that *Spartina stricta* has 56, *S. alternifolia* has 70, and *S. townsendii* has 126. *Townsendii* is a polyploid from a combination of *alternifolia* and *stricta*. It breeds true and will not cross with its ancestral types because polyploidy confers a high degree of incompatibility. The hemp nettle, *Galeopsis tetrahit* has arisen in the same sort of way from two diploids, *G. pubescens* with 16 chromosomes and *G. speciosa* with 16 chromosomes: and in 1932 Müntzing (1932) succeeded in crossing *G. pubescens* and *G. speciosa* and producing a 'synthetic' hybrid, exactly like *G. tetrahit*.

These are examples of genetic isolation. It is evident that species can arise without geographical isolation. It is enough for there to be a gene mutation which makes the individual unable to breed with the rest of the race. By polyploidy, or by the breaking up and rejoining of chromosomes during cell division, races can be formed which may live alongside the rest of the species and yet be isolated from it. Once the race has been isolated, then it will run its own course of evolution; it will change and be diversified by mutations, untouched by the main group from which it has become detached. Thus it is possible for races to diverge, and to evolve into new species, without natural selection. There may be no difference in fitness between the new race and the mother community. That will not matter. Mutations will continue to arise in the new race, and especially in small populations, selection will be weak. Under these conditions there can certainly be an origin of species without geographical or ecological isolation, and not dependent on natural selection.

But selection is ever waiting, as it were, to work on differences in fitness, and we have some interesting evidence that polyploids in general are fitter than the diploids from which they come. For instance, almost all grasses at Spitzbergen are, according to Haldane, polyploids. Other polyploid grasses are common in deserts (Hagerup, 1932). On theoretical grounds, too, polyploids should be 'fitter,' because when there are four or six outfits of chromosomes instead of two there is less chance of harmful genes weakening the race: there is more chance that they are masked by the dominant genes in other chromosomes.

Finally, I shall mention one example of the historical evidence for evolution by polyploids. There is a European crucifer, *Biscutella laevigata*, which occurs in both diploid and tetraploid forms. Manton (1934), has shown how the diploid forms are confined to valleys not covered by ice at the last glacial period. The tetraploid forms occupy stretches of Europe once covered by ice. It appears that the diploid *Biscutella* is a vestige of the flora of Europe before the Ice Age, and the tetraploid *Biscutella* has succeeded it except in a few areas (fig. 4).

FIG. 4.—Distribution of diploid and tetraploid species of *Biscutella* in Europe. (after Manton.)

It is time to sum up. The centenary of this Society falls at a time when interest in evolution has revived, at a time when evolution is being studied more vigorously than ever before. Many of the blank spaces in the map of evidence Darwin relied upon have been filled in. We ought to know our way about nature better than he, for we have far more powerful instruments for exploration. We have fuller confirmation than Darwin had of the fact that evolution has occurred. We have more evidence of the working of natural selection to produce new forms. For Darwin's assumption of inheritance by blending we can substitute the beautiful, clear mechanisms revealed by genetics. For Darwin's confession that he did not know the causes of variation we can substitute our knowledge of gene mutation; of inversion, translocation, polyploidy, and the reaction of the whole outfit of genes to a change in any one of them. Where Darwin relied on observation we can use the sharper instrument of experiment. Where Darwin imagined one origin of species, we recognise several origins of species: where he assumed one process of evolution, we assume many processes. Yet Darwinism is not out of date. In the study of evolution the scientific victories of the 1940's depend on the master strategy laid down in the 1840's.

One more point: the last. In the study of evolution much has been accomplished, but much remains to be done. We know a good deal about the origins of species, but we still have no adequate hypothesis to explain the grand sweep of evolution. With all our experience we cannot account for the evolutionary trends in such groups as the ferns or gymnosperms, ammonites or spirifers. This

is only one example of our ignorance. In fact, it would not be difficult to give another lecture on the unsolved problems of evolution: problems about which we are as ignorant to-day as our predecessors were in 1843.

It is gratifying to recall that Tasmania has the honour of a rare compliment from Darwin, and that the City of Hobart played a part in the first stage of the intellectual adventure I have described to-night. Over and over again Darwin acknowledged his debt to Sir Joseph Hooker, and he drew some of his evidence from Hooker's work. In 1854 the Tasmanian Government made an unsolicited grant of money towards the cost of publishing Hooker's Flora of Tasmania. Hooker wrote to Darwin to tell him of this. Here is Darwin's reply (Darwin, 1887, vol. i):

> 'What capital news from Tasmania: it really is a very remarkable and creditable fact to the colony. I am always building veritable castles in the air about emigrating, and Tasmania has been my headquarters of late: it is really a very singular and delightful fact, contrasted with the slight appreciation of science in the old country.'

It has been a pleasure to discuss Darwin's work in a city which earned this high compliment from him.

LITERATURE CITED

Darwin, C., 1900.—*The Origin of Species*, 6th Edition. Historical Sketch.

Darwin, F., 1887.—*Life and Letters of Charles Darwin.* 3 Vols.

Dobzhansky, T., 1937.—*Genetics and the Origin of Species*, p. 235.

Engledow, F. M., 1925.—Investigation on Yield in the Cereals. *Journ. Agric. Science*, Vol. XV, p. 124.

Fisher, R. A., 1930.—*Genetical basis of Natural Selection.* Oxford.

Gordon, C., 1935.—Experiment on a released population of *D. melanogaster*. *Amer. Nat.*, Vol. LXIX, p. 381.

Gregor, J. W., 1939.—Experimental Taxonomy, IV. *New Phyt.*, XXXVIII, p. 293.

Gulick, A., 1938.—What are the Genes? *Quart. Rev. Biol.*, Vol. 13, p. 140.

Gunn, R. C., 1846.—Communicating a letter from E. C. Hobson on fossil bones from Mount Macedon. *Tas. Journ.*, Vol. II, p. 344.

Gunn, T. C., 1842.—Observations on the flora of Geelong. *Tas. Journ.*, Vol. I. p. 203.

Hagerup, O., 1932.—Über Polyploidie in Beziehung zu Klima, Ökologie u. Phylogenie. *Heriditas*, XVI, p. 19.

Haldane, J. B. S., 1932.—*The Causes of Evolution.* London.

Harland, S. C., 1936.—The Genetical Conception of the species. *Biol. Rev.*, Vol. XI, p. 83.

Huskins, C. L., 1931.—The origin of *Spartina townsendii*. *Genetica*. Vol. XII, p. 531.

Huxley, J., 1942.—*Evolution: The Modern Synthesis.* London.

Huxley, T. H., 1907.—The Coming of Age of the Origin of Species. *Collected Essays.* Vol. II.

Jukes, J. B., 1846.—A few remarks on the nomenclature and classification of rock formations. *Tas. Journ.*, Vol. II, p. 1.

Lamprecht, H., 1941.—The Limit between *Phaseolus vulgaris* and *P. multiflorus*. *Proc. VII, Int. Cong. Genetics*, p. 179.

Manton, I., 1934.—The problems of *Biscutella laevigata* Z.I.A.V., LXVII. p. 41.

MUNTZING, A., 1932.—Cytogenetic investigations on synthetic *Galeopsis tetrahit*. *Hereditas*, XVI, p. 105.

PEARSON, J., 1938.—The Tasmanian Black Brush Opossum. *Papers & Proc. Roy. Soc. Tas.*, 1937, p. 21.

REUSCH, B., 1939.—Typen der Artbildung. *Biol. Rev.*, XIV, p. 180.

ROBSON, G. C. and RICHARDS, O. W., 1936.—*The Variation of Animals in Nature*. London.

SALISBURY, L. J., 1929.—The biological equipment of species in relation to competition. *Jour. Ecol.*, XVII, p. 197.

SPENCER, W. P., 1941.—Ecological factors and the distribution of genes in *D. hydei* populations. *Proc. VII, Int. Cong. Genetics*, 1939, p. 268.

VAVILOV, N. G., 1922.—The Law of Homologous Series in Variation. *Jour. Genetics*, XII, p. 47.

WADDINGTON, C. H., 1939.—*Introduction to Modern Genetics*, p. 270. London.

WRIGHT, S., 1935.—A mutation in the guinea pig. Genetics, XX, p. 84.

Pap. & Proc. Roy. Soc. Tasmania, 1943 (15th December, 1944.)

On some new Australian Apneumonomorphae with Notes on their Respiratory System

By

V. V. Hickman

Ralston Professor of Biology, University of Tasmania

(Read 16th November, 1943)

Plates I-V

Three families of apneumone spiders are now recognized, namely, the Telemidae, Symphytognathidae, and Caponiidae. Of these, only the Symphytognathidae have been recorded from Australia. There is little doubt, however, that many apneumone species occur in this region. Some genera, formerly regarded as belonging to the Dipneumonomorphae, are now known to lack book-lungs and to have a respiratory system consisting of tracheal tubes only. Dr. L. Fage (1937, p. 97) states that *Chasmocephalon* and several other genera placed in the Theridiidae are apneumone. In the present paper, I have described a new species of *Chasmocephalon* from Tasmania, and am able to confirm Fage's statement in regard to the respiratory system of this genus.

The Victorian genera *Micropholcomma* and *Microlinypheus* are also shown to lack book-lungs and are therefore removed from the Theridiidae and Linyphiidae respectively. Moreover, *Microlinypheus* is regarded as a synonym of *Micropholcomma*. Two new species belonging to this genus are recorded from Tasmania.

In order to accommodate the species of *Micropholcomma* in the sub-order Apneumonomorphae, it is necessary to establish a new family, for which the name Micropholcommatidae is suggested. A definition of the family and descriptions of the species are given below. Brief notes on the respiratory systems of *Chasmocephalon* and *Micropholcomma* are also added.

Branch PROTEROTRACHEATAE

Family SYMPHYTOGNATHIDAE

Genus **Chasmocephalon** Cambridge, 1889

The following is a revised definiton of the genus: Carapace high in front and sloping steeply to the posterior margin. Cervical groove in the form of a deep cleft. Eight eyes in two rows. Viewed from in front the anterior row is procurved. AME very small and contiguous. Clypeus very high. Chelicerae with three teeth. Tarsi about twice the length of the metatarsi. Few trichobothria on tibiae. A single trichobothrium on the first and second metatarsi, but none on the third and fourth metatarsi. A tarsal organ or 'drum' on all tarsi. Three

tarsal claws are present. Scopulae and claw-tufts absent. Female with reduced palpi. A dorsal scute is present on the abdomen in the male. Epigastric scute, mammillary ring, six spinnerets and a colulus are present in both sexes. Book-lungs and posterior tracheal spiracles are absent. A pair of anterior tracheal spiracles is present from which tubes are supplied to both cephalothorax and abdomen.

Spiders belonging to the genus are very small. They live among moss and fallen leaves, where they spin orbicular webs like those of the Argiopidae. The webs are suspended horizontally. The egg-sac is made of white silk and has the shape of a small bowl.

Chasmocephalon minutum, sp. n.

Male

	mm.
Total length	0·6713
Length of cephalothorax	0·3699
Width of cephalothorax	0·3288
Length of abdomen	0·5891
Width of abdomen	0·4658

Leg.	Femur.	Patella.	Tibia.	Metatarsus.	Tarsus.	Total.
1	0·3014	0·1233	0·2329	0·1233	0·2466	1·0275
2	0·2329	0·1096	0·2055	0·1096	0·2397	0·8973
3	0·1918	0·0959	0·1644	0·0959	0·2055	0·7535
4	0·2466	0·1096	0·2055	0·1096	0·2329	0·9042
Palp	0·1233	0·0685	0·0685	....	0·0959	0·3562

Colour. Dark brown. Sternum and margin of dorsal scute on abdomen darker than other parts. On the clypeus a pair of dark lines from ALE and a median line from AME extend downwards and meet at the middle of the margin, thus forming a bisected V.

Carapace. High and convex. The head region, when viewed from the side, appears rounded and projects slightly over the clypeus. The slope from the head region to the posterior margin of the carapace is very steep. Cervical groove forms a deep cleft on each side. The margins of the clefts are furnished with small tubercles. The dorsal surface of the head region is smooth, but the sides are slightly granulose. Thorax is marked with coarse ridges and tubercles. There is a pair of erect hairs behind the cervical groove and a pair in front. There are also two hairs in a median row behind PME, two on each side between PME and PLE, and two between PME and AME. A single hair is situated immediately in front of AME, and a few short hairs are on the clypeus and at the sides of the head (pl. I, fig. 1).

Eyes. The eight eyes form a group which occupies the full width of the head. Viewed from above, both rows of eyes appear recurved. Viewed from in front they appear procurved (pl. I, fig. 2). AME are the smallest of the group and are mounted on a small, black tubercle. Ratio of eyes AME : ALE : PME : PLE = 5 : 12 : 10 : 11. The AME are separated from each other by 2/5 and from ALE by 9/5 of their diameter. The lateral eyes are contiguous. PME are separated from each other by 4/5 and from PLE by 14/5 of the diameter of AME. The median ocular quadrangle is twice as wide behind as in front. Its length is greater than its posterior width in ratio 25 : 22. The height of the clypeus in front of AME is about nine times the diameter of AME.

Chelicerae. Condyles and stridulating ridges absent. The basal segment is 0·126 mm. long. Fang well curved. Three moderately large teeth are present on the promargin. Of these the tooth farthest from the base of the fang is the largest. Near the base of the fang is a group of four minute teeth. A retrolateral scopula of five barbed hairs is present (pl. I, fig. 3).

Maxillae. Triangular, converging in front of labium, clothed with about seven long hairs. Outer margin rounded. A small apical scopula and a well-developed serrula composed of about twenty teeth are present.

Labium. Immobile. Wider than long in ratio 18 : 7. Apex wide and emarginate. Provided with two hairs, one on each side.

Sternum. Strongly convex, cordiform, longer than wide in ratio 65 : 58. Produced anteriorly between the bases of the maxillae. Widest between the second coxae. Rounded posteriorly between the fourth coxae, which are widely separated. The surface is coarsely pitted and clothed with a few hairs.

Legs. 1.4.2.3. Lightly clothed with simple hairs. The tarsi are twice as long as the metatarsi. Spines are absent, but there is a large, erect bristle at the apex of each patella and 1 – 1 bristles on each tibia. Three trichobothria are situated on the basal half of the first three pairs of tibiae and four on the fourth pair. A single trichobothrium is present near the middle of the first and second metatarsi, but none on the third and fourth metatarsi. Each tarsus has a 'drum' on the dorsal side near the base. Three tarsal claws are present and all are devoid of teeth.

Palpi. The genital bulb is large and has the form shown in pl. I, figs 4 and 5. One of its most conspicuous features is a dark, three-pointed apophysis, between two of the prongs of which the embolus passes. The cymbium is spoon-shaped and clothed with a few long hairs. Two or three setae at the apex are sigmoid in shape. On the prolateral side the tibia is produced into a short, blunt apophysis and the patella has a small projection near the apex. Trichobothria and tarsal 'drum' are not present on the palpi.

Abdomen. Partly overhangs the carapace. The dorsal surface is covered by a hard chitinous scute clothed with minute hairs. A large epigastris scute covers most of the ventral surface (pl. I, fig. 1). It has a foramen for the petiolus, and on each side of the foramen a round sclerite is incorporated in the scute. About half way between these sclerites and the posterior margin of the scute are the two tracheal spiracles, one on each side (pl. I, fig. 6). Book-lungs and posterior tracheal spiracles are absent. In a median position behind the epigastric scute is a small rectangular sclerite. Six spinnerets and a small colulus are present. They are protected by a partial ring of chitin, which extends round them dorsally and laterally, but is incomplete ventrally. The anterior spinnerets are the largest of the group.

Female	mm.
Total length	0·7672
Length of cephalothorax	0·4110
Width of cephalothorax	0·3151
Length of abdomen	0·6302
Width of abdomen	0·5206

Leg.	Femur.	Patella.	Tibia.	Metatarsus.	Tarsus.	Total.
1	0·2740	0·1233	0·2329	0·1233	0·2466	1·0001
2	0·2466	0·1096	0·2055	0·1096	0·2329	0·9042
3	0·1918	0·0959	0·1781	0·0959	0·2192	0·7809
4	0·2603	0·1233	0·2192	0·1096	0·2329	0·9453

The female is slightly larger than the male and very dark brown, almost black, in colour. It also differs from the male in lacking a dorsal scute on the abdomen. In other respects there is a close resemblance between the two sexes, and therefore only the following characters need be described.

Palpi. As in other members of the genus the palpi are vestigial, being reduced to the coxa and maxillary lobe.

Abdomen. Broadly ovate. Dorsal surface tough and leathery, but without a rigid chitinous scute. A number of small, rounded sclerites are arranged in rows at the sides. On the ventral surface there is a large epigastric scute resembling that of the male. In a median position and immediately behind the epigastric scute is a small sclerite having a transverse procurved ridge. In surface view the epigynum consists of a slight median emargination of the posterior edge of the epigastric scute. On each side of the emargination the chitin is thickened. In transparent preparations the epigynum has the form shown in pl. I, fig. 7. The six spinnerets and colulus are protected by a partial ring of chitin, as in the male.

Locality. Tasmania: Cascades, 26th June, 1943, two males and two females. Mount Wellington (3000 ft.), 23rd July, 1943, seven males and four females. All the specimens were found amongst moss and fallen leaves.

Habits, Web, and *Egg-sac.* As previously mentioned, *Chasmocephalon minutum* lives amongst moss and fallen leaves on the ground, usually in moist situations. As the spider is little more than half a millimetre in length, its habits had to be studied under laboratory conditions. Specimens were kept in glass tubes and also in small cells made of plaster of Paris. The spiders thrived best in an atmosphere saturated with moisture and soon died under dry conditions. A glass tube only 10 mm. in diameter was wide enough for a complete orbicular web to be constructed within it. A web made among moss in a plaster cell, where its size was not in any way restricted, measured only 10 mm. in diameter. It had ten rays. The meshed hub was 0·6 mm. across and the free space 0·9 mm. The viscid spiral consisted of about 30 turns, adjacent turns being separated by 0·15 mm. In a length of one millimetre there were 430 viscid droplets arranged close together on the spiral. The web was suspended horizontally, with its centre drawn up slightly by means of a vertical thread. The spider rested at the hub on the underside and dropped immediately if disturbed.

Very small Collembola were found to be a suitable food, but were only accepted if caught in the web. On 8th August, 1943, one of the spiders made a white egg-sac, which resembled a small bowl covered with a lid, and was attached to a piece of moss. It measured 1·16 mm. in diameter and 0·87 mm. high, and contained two eggs. An egg-sac made by another specimen on 25th August, 1943, contained four eggs. From this latter sac the young ones emerged on 24th October, 1943. There were two males and two females. Even at this early stage the palpi of the females consisted of nothing more than the coxal segment with its maxillary lobe.

Family MICROPHOLCOMMATIDAE, nov.

Cribellum and calamistrum wanting. Colulus and six spinnerets present. Book-lungs absent. A pair of anterior tracheal spiracles and a single median posterior tracheal present. A single pair of stout trachael tubes pass from the anterior spiracles into the cephalothorax, where they branch into small tracheae. The abdomen is supplied with tubes from both the anterior and posterior spiracles. No tubes from the posterior spiracle enter the cephalothorax. Eight eyes are present. Chelicerae without boss. Margins oblique and toothed. Lip immobile. Maxillae converging, with scopula and serrula. Legs prograde. Three claws. Scopulae, onychium and claw tufts wanting. Trichobothria few and present on tibiae only, none elsewhere. A tarsal organ or 'drum' on tarsi. Pedipalp of female vestigial or with less than six segments and without a claw. Abdomen with dorsal and epigastric scutes and a chitinous ring round the spinnerets.

Genus **Micropholcomma** Crosby and Bishop, 1927

With the characters of the family. Anterior median eyes the smallest. Posterior row of eyes longer than front row. Ocular quadrangle wider behind than in front. Prolateral surface of first femora provided with small tubercles or granulations. Tarsi about double the length of the metatarsi. Upper claws similar and pectinate in a single row.

Genotype. Micropholcomma caeligenus Crosby and Bishop.

KEY TO SPECIES

Males

1. First pair of legs with sinuous tarsi ..... *M. parmata* sp. n.
   First pair of legs with normal tarsi 2
2. Second tibiae with one trichobothrium ..... *M. mira* sp. n.
   Second tibiae with two trichobothria 3
3. AME separated from ALE by 1/3 diameter of AME ..... *M. caeligenus* Crosby and Bishop
   AME separated from ALE by 1/7 diameter of AME ..... *M. bryophila* (Butler)

Females

1. Palpi reduced to five segments ..... *M. bryophila* (Butler)
   Palpi reduced to coxal segment and maxillary lobe 2
2. Second tibiae with two trichobothria ..... *M. caeligenus* Crosby and Bishop
   Second tibiae with one trichobothrium 3
3. Dorsal scute of abdomen smooth ..... *M. parmata* sp. n.
   Dorsal scute of abdomen pitted ..... *M. mira* sp. n.

Micropholcomma caeligenus Crosby and Bishop

Amongst a number of small spiders collected at Lorne, Victoria, by Mr. C. Oke, and sent to me for description, are several specimens which agree very closely with *Micropholcomma caeligenus* Crosby and Bishop. As the female has not been described and some additional characteristics of the male need recording, the following descriptions of both sexes are given.

Male

	mm.
Total length	0·8905
Length of cephalothorax	0·4384
Width of cephalothorax	0·3425
Length of abdomen	0·6850
Width of abdomen	0·5617

Leg.	Femur.	Patella.	Tibia.	Metatarsus.	Tarsus.	Total.
1	0·2192	0·1096	0·1781	0·0822	0·1781	0·7672
2	0·2055	0·1096	0·1507	0·0822	0·1644	0·7124
3	0·1918	0·0959	0·1370	0·0822	0·1781	0·6850
4	0·2329	0·1233	0·2055	0·0959	0·2055	0·8631
Palp	0·0548	0·0685	0·0420	....	0·0660	0·2313

Colour. The ground colour is golden brown. Carapace mottled with dark markings. A dark rectangular patch on the highest part of carapace. Interocular region black. Chelicerae, palpi and legs yellowish. Sternum golden brown mottled with black. Dorsal and epigastric scutes of abdomen golden brown. Soft integument of abdomen greyish yellow.

Carapace. Gently rounded at the sides. Very high, its highest point being above a line between the second coxae. From here it slopes gently downward to the eyes and very steeply to the hind margin. Head region smooth. Thoracic part finely shagreened. A pair of erect, curved bristles situated on the highest part of the carapace, and a single median bristle a short distance in front of them. Several shorter hairs are present on the head and in the eye-region.

Eyes. Eight, arranged in two rows. The eye-group occupies almost the full width of the head. Posterior row longer than front row in ratio 13 : 11. Viewed from above the posterior row is straight and the front row recurved. Viewed from in front the anterior row is distinctly procurved, the ALE being nearer the margin of the clypeus than are the AME. Ratio of eyes AME : ALE : PME : PLE = 9 : 14 : 11 : 12. AME are separated from each other by 4/9 and from ALE by 3/9 of their diameter. The lateral eyes are continguous. PME are separated from each other by a space equal to the diameter of AME and from PLE by 8/9 of the diameter of AME. The median ocular quadrangle is wider behind than in front in ratio 30 : 21. Its length is less than its posterior width in ratio 23 : 30. The height of the clypeus in front of AME is slightly less than four times the diameter of AME.

Chelicerae. Strong and stout. Devoid of condyles and stridulating ridges. Fang well curved. Margins oblique. Promargin provided with two stout spines near base of fang and two teeth. Retromargin with one tooth. Behind the retromargin is an oblique row of five barbed hairs forming a light scopula. Front surface clothed with 8 or 9 simple hairs.

Maxillae. Triangular. Converging in front of labium. Provided with a small apical scopula and a well developed serrula.

Labium. Immobile, much wider than long, slightly emarginate in front and provided with five hairs in a transferse row.

Sternum. Smooth, cordiform, convex, as wide as long, widest immediately in front of second coxae, rebordered and squarely truncate behind. Clothed with about 18 hairs on each side. Middle region devoid of hairs. Fourth coxae widely separated.

Legs. 4.1.2.3. Tarsi more than twice the length of metatarsi. Spines absent. There are a few small granules on the prolateral side of the first femora. Some of the granules form a group near the base of the segment. Tibiae stout. Patellae with a retrolateral bulge. Two trichobothria on tibiae of first three pairs of legs, three on those of fourth pair. No trichobothria on other segments. A tarsal organ or 'drum' is present on the dorsal side of each tarsus near the base. Scopulae and claw tufts absent. Three tarsal claws present. Upper claws provided with about four small teeth, which are larger on the claws of the front

two pairs of legs than on those of the other legs. The lower claw appears to be bare. Legs are clothed with long hairs, those on the ventral side of all the tarsi being distinctly barbed, but they do not form a 'comb' on the fourth tarsi.

Palpi. Very small, not much longer than the femora of first pair of legs. Femur short and stout. Patella longer than femur and produced into a short, pointed apophysis on the retrolateral side. Tibia short and expanded distally. It arises on the prolateral side of the patella. Tarsus spoon-shaped. Embolus rises from the outer surface of the genital bulb and makes one complete turn. Four long hairs are situated along the edge of the cymbium and project over the bulb. Trichobothria and tarsal drum are lacking. See figure of palpus given by Crosby and Bishop (1927, pl. XVI, fig. 19).

Abdomen. Dorsal surface covered by a hard shield. The soft integument at the sides of the abdomen forms a fold parallel with the edge of the scute and also two other folds which pass obliquely downwards towards the spinnerets. A great part of the ventral surface is covered by a large epigastric scute which extends forwards round the base of the pedicle. The posterior margin of the scute is produced backwards into two lobes, one on each side. Book-lungs are absent. A pair of anterior tracheal spiracles is situated in the notches formed between the epigastric scute and its posterior lobes. A single median tracheal spiracle opens immediately in front of the colulus and is partly hidden by the posterior margin of the chitinous ring that surrounds the spinnerets. Six spinnerets are present, the anterior pair being the largest. The small colulus is pyriform and provided with two hairs on its ventral surface. The abdomen is clothed with hairs. A number of small rounded sclerites is incorporated in the dorsal scute and form a sub-marginal row readily seen in cleared specimens.

Female

	mm.
Total length	0·9864
Length of cephalothorax	0·4384
Width of cephalothorax	0·3562
Length of abdomen	0·7809
Width of abdomen	0·6439

Leg.	Femur.	Patella.	Tibia.	Metatarsus.	Tarsus.	Total.
1	0·2329	0·1096	0·1644	0·1027	0·1781	0·7877
2	0·2192	0·1233	0·1507	0·0959	0·1781	0·7672
3	0·2055	0·1096	0·1370	0·0891	0·1781	0·7193
4	0·2603	0·1096	0·2055	0·1027	0·2055	0·8836

The female closely resembles the male in colouration and general appearance. Hence only the following characters need be described.

Palpi. Vestigial, being reduced to the coxa, maxillary lobe and a small tubercle-like projection on the outer side of the coxal segment near the base (pl. II, fig. 8).

Abdomen. Dorsal scute, epigastric scute and tracheal spiracles as in the male. A pair of spermathecal aperatures open on the epigastric scute just in front of its posterior margin. They are between and almost in line with the notches formed between the scute and its posterior lobes (pl. II, fig. 9). The form of the epigynum viewed as a transparent object is shown in pl. II, fig. 10.

Locality. Victoria: Lorne. Four males and four females collected from moss by Mr. C. Oke.

Micropholcomma bryophila (S. Butler)

This small spider was described under the name of *Microlinypheus bryophilus* by Mr. S. Butler (1932, p. 104). The type specimens were collected at Lorne, Victoria, by Mr. C. Oke, who has been good enough to send me several examples of the same species from the same locality. These agree very closely with Mr. Butler's description, but, in my opinion, the spider belongs to the genus *Micropholcomma*. The following revised descripton of both sexes is therefore given:—

Male

	mm.
Total length	0·7672
Length of cephalothorax	0·3836
Width of cephalothorax	0·3014
Length of abdomen	0·5754
Width of abdomen	0·4795

Leg.	Femur.	Patella.	Tibia.	Metatarsus.	Tarsus.	Total.
1	0·1918	0·0959	0·1644	0·0959	0·1644	0·7124
2	0·1781	0·0959	0·1507	0·0822	0·1575	0·6644
3	0·1644	0·0822	0·1507	0·0822	0·1507	0·6302
4	0·2055	0·0959	0·1918	0·0959	0·1781	0·7672
Palp	0·0506	0·0655	0·0447	....	0·0745	0·2353

Colour. Golden brown. Carapace and sternum mottled with black.

Carapace. Gently rounded at the sides. Somewhat narrowed and bluntly rounded in front. Viewed from the side it rises very steeply from the posterior margin, reaching its highest point above a line between the second coxae. It then slopes gently downwards to the eyes. Head-part smooth. Thoracic part finely granular. A pair of erect, curved bristles on the highest part of the carapace and a single median bristle a short distance in front of them. A few shorter hairs at the sides of the head and in the eye-region.

Eyes. Eight, arranged in two rows, the posterior row being longer than the front row in ratio 8 : 5. The eye-group occupies the full width of the head. Viewed from above both rows appear very slightly recurved, almost straight. Viewed from in front the anterior row is distinctly procurved, the lateral eyes being nearer the edge of the clypeus than are the median eyes. Ratio of eyes AME : ALE : PME : PLE = 7 : 11 : 11 : 11. AME are separated from each other by 2/7 and from ALE by 1/7 of their diameter. The lateral eyes are contiguous. PME are separated from each other by 6/7 and from PLE by 5/7 of the diameter of AME. The median ocular quadrangle is wider behind than in front in ratio 26 : 16. Its length is shorter than its posterior width in ratio 20 : 26. The height of clypeus in front of AME is 25/7 of the diameter of AME.

Chelicerae. Strong, stout, and very slightly diverging. Lateral condyles and stridulating ridges absent. Fang strong and curved. Margins oblique. Promargin with two stout spines near base of fang and two small teeth. Retromargin with one tooth. Behind the retromargin is an oblique row of five barbed hairs forming a light scopula. Front surface with a few long hairs.

Maxillae. Converging in front of labium. Provided with a light scopula at the apex and a serrula of about 21 teeth on the anterior margin.

Labium. Immobile, much wider than long, slightly emarginate in front and provided with a transverse row of five hairs.

Sternum. Convex, cordiform, longer than wide in ratio 17 : 16. Widest between the second coxae. Margin rebordered. Truncate between the fourth coxae, which are widely separated. Clothed with a few long hairs.

Legs. 4.1.2.3. Tarsi almost twice the length of the metatarsi. Spines absent. First femora with a few small granules on the prolateral surface near the base. Two trichobothria on the tibae of the first three pairs of legs and three on those of the fourth pair. No trichobothria on other segments. Tarsal organ or 'drum' on the dorsal side of each tarsus near the base. Scopulae and claw tufts absent. Three tarsal claws present. The upper claws appear to have a few very small teeth, but the number could not be seen clearly. The lower claw has one tooth. Legs clothed with long hairs, those on the ventral side of the tarsi being barbed. There is no 'comb' on the fourth tarsi.

Palpi. Very small, slightly longer than the first femora. Femur short and stout. Patella longer than femur and produced into a blunt-pointed apical apophysis on the retrolateral side. Tibia short and expanded distally. It is attached to the prolateral side of the patella. Tarsus spoon-shaped and clothed with about seven long hairs. Embolus makes one complete turn on the surface of the bulb (pl. II, fig. 11). The palpi closely resemble those of the other three species in the genus.

Abdomen. Dorsal surface covered by a hard chitinous shield lightly clothed with short hairs. The soft integument at the sides of the abdomen forms a series of folds as in the preceding species. Ventral surface is provided with a large epigastric scute which extends forward round the base of the pedicle. The posterior margin of the scute is produced backwards into two lobes, one on each side. Book-lungs are absent. A pair of anterior tracheal spiracles is situated, one on each side, in the notches formed between the scute and its posterior lobes. A single median posterior tracheal spiracle is situated immediately in front of the spinnerets and on the posterior margin of the chitinous ring which surrounds them. Six spinnerets and a colulus are present. The colulus is provided with two hairs. The anterior spinnerets are the largest of the group.

Female

	mm.
Total length	0·8220
Length of cephalothorax	0·3836
Width of cephalothorax	0·3014
Length of abdomen	0·6850
Width of abdomen	0·5480

Leg.	Femur.	Patella.	Tibia.	Metatarsus.	Tarsus.	Total.
1	0·2055	0·0959	0·1644	0·0822	0·1781	0·7261
2	0·1918	0·0959	0·1644	0·0822	0·1644	0·6987
3	0·1644	0·0959	0·1370	0·0822	0·1644	0·6439
4	0·2329	0·0959	0·1918	0·0959	0·1644	0·7809

The female resembles the male in colour and general appearance. Hence only the following characters need be described.

Eyes. The eye-group occupies the full width of the head. AME are somewhat smaller than in the male. Ratio of eyes AME : ALE : PME : PLE = 6 : 11 : 11 : 11. The AME are separated from each other by half their diameter and are almost contiguous with ALE. The PME are separated from each other by a space equal to once the diameter of AME, and by the same distance from the PLE. The lateral eyes are contiguous. The median ocular quadrangle is wider behind than in front in ratio 26 : 15. Its length is less than its posterior width in ratio 20 : 26. The height of the clypeus in front of AME equals 25/6 times the diameter of AME.

Chelicerae, maxillae, labium, sternum and *legs* as in the male.

Palpi. Very small, being only 0·153 mm. long and consisting of only five segments. This interesting feature was recorded by Mr. Butler (1932, p. 106), who considered that the patella was lacking. In my opinion, however, the patella is present and the apparent loss of a segment is due to the fusion of the tibia with the tarsus. There is a slight constriction where one would expect the joint between the tibia and tarsus to be, but no actual joint is present (pl. II, fig. 12). The measurements of the separate segments of the palp are as follows. Trochanter 0·021 mm., femur 0·045 mm., patella 0·033 mm., tibiotarsus 0·054 mm. The appendage is provided with a few long hairs, but trichobothria, tarsal 'drum' and claw are lacking.

Abdomen. Dorsal surface completely covered by a hard scute. Integument at the sides of the abdomen forms a series of folds as in preceding species. A large epigastric scute covers more than half of the ventral surface and extends round the pedicle so that the foramen for the pedicle is near the centre of the scute. Posteriorly the scute is produced backwards into two lobes, one on each side, as in other members of the genus. Book-lungs are wanting. Tracheal apertures as in male. A pair of spermathecal openings are situated on the scute a short distance in front of the posterior margin (pl. II, fig. 13). The form of the epigynum as seen in transparent preparations is shown in pl. II, fig. 14.

Six spinnerets and a colulus are present and resemble those of the male. They are surrounded by the usual chitinous ring.

Locality. Victoria: Lorne. Three males and three females collected by Mr. C. Oke.

Micropholcomma parmata, sp. n.

Male

	mm.
Total length	1·0001
Length of cephalothorax	0·4795
Width of cephalothorax	0·3699
Length of abdomen	0·7535
Width of abdomen	0·6028

Leg.	Femur.	Patella.	Tibia.	Metatarsus.	Tarsus.	Total.
1	0·2740	0·1096	0·2055	0·0959	0·2329	0·9179
2	0·2466	0·1096	0·1644	0·0822	0·2192	0·8220
3	0·2192	0·1096	0·1507	0·0959	0·2055	0·7809
4	0·2740	0·1096	0·2192	0·1096	0·2192	0·9316
Palp	0·0626	0·0387	0·0447	....	0·0894	0·2354

Colour. Carapace and dorsal scute of abdomen chestnut-brown. A dark rectangular patch on posterior part of head. Margin of carapace suffused

with black. Interocular space black. A dark median line behind PME and a similar dark line on each side behind PLE extend backwards to the dark rectangular patch on the posterior part of the head. Sternum brown, suffused with black. Legs and ventral surface of abdomen light brown.

Carapace. Viewed from above its outline is broadly pyriform. Rounded in front and at the sides. Viewed from the side it appears very high, its highest point being above a line between the second coxae. From here it slopes gently downwards to the eye-region and very steeply downwards to the posterior margin (pl. III, fig. 18). The thoracic part is finely granular, the head part smooth. From the highest part arises a pair of long, erect bristles, which curve forward. A similar median bristle is situated a short distance in front of them. Several short hairs are also present on the head.

Eyes. Eight, arranged in two rows. The posterior row is longer than the front row in ratio 13 : 11. The eye-group occupies almost the full width of the head region in front. Viewed from above the posterior row is straight and the anterior row slightly recurved. Viewed from in front the anterior row is procurved, the ALE being nearer the margin of the clypeus than are the AME. Ratio of eyes AME : ALE : PME : PLE = 11 : 16 : 12 : 14. AME are separated from each other by 4/11 and from ALE by 2/11 of their diameter. The lateral eyes are contiguous. PME are separated from each other by a space equal to the diameter of AME and from PLE by 8/11 of the diameter of AME. The height of the clypeus in front of AME is about 37/11 of the diameter of AME. There is a median hair in front of AME and two hairs on each side in front of ALE (pl. III, fig. 15).

Chelicerae. Stout and strong. Devoid of lateral condyles and stridulating ridges. Fang strong and well curved. Margins oblique. Promargin provided with two short spines near base of fang and two teeth. Retromargin with one small tooth. Behind the retromargin is an oblique row of five barbed hairs forming a light scopula. Front surface furnished with about eight long hairs (pl. III, fig. 15).

Maxillae. Converging in front of labium. Somewhat triangular in shape. Provided with an apical scopula and a well developed serrula.

Labium. Immobile, much wider than long, slightly emarginate in front and provided with five hairs in a transverse row.

Sternum. Convex, cordiform, as wide as long, widest immediately in front of second coxae, margin rebordered, squarely truncate between the fourth coxae, which are separated by about 8/5 of their diameter. Surface of sternum shagreened and furnished with a few long hairs.

Legs. 4.1.2.3. Tarsi more than twice the length of the metatarsi. The first tarsi sinuous and somewhat narrowed towards the base (pl. III, fig. 16). They are provided with three short, stout spines on the prolateral surface, the largest spine being near the middle of the segment. There are no other spines present on any of the legs. The first femora have a group of small granules near the base on the prolateral surface and a few similar granules on the ventral surface. There are two trichobothria on the first tibiae, one on the second, two on the third, and three on the fourth. Elsewhere there are none. All the patellae have a distinct bulge on the retrolateral side. A tarsal organ or 'drum' is situated on the dorsal side of each tarsus near the base. Three tarsal claws are present. The upper claws are similar and provided with a few small teeth. The lower claw is without teeth. Scopulae and claw-tufts are absent. The legs are

clothed with long hairs, those of the ventral surface of the second, third, and fourth tarsi being distinctly barbed. There is no 'comb' however on the fourth tarsi.

Palpi. Very small, not as long as the first femora. The tibia is short and broad, articulating with the prolateral side of the patella. The patella is somewhat ovoid and produced into a short, black point on the retrolateral side at the apex. Near the base on the retrolateral side it is provided with a series of fine longitudinal ridges (pl. III, fig. 17). The femur is short and stout. The genital bulb resembles that of the other species in the genus. The embolus arises on its surface and makes one complete turn. Four long hairs on the retrolateral edge of the cymbium project over the bulb.

Abdomen. Dorsal surface covered by a smooth, chitinous scute, which is clothed with moderately long hairs. It is marked with a row of round, submarginal spots, due to the presence of small sclerites incorporated in the scute. Near the middle of the scute are two pairs of muscle spots. The soft integument at the side of the abdomen forms a fold just below and in contact with the edge of the dorsal scute. Beneath this fold and parallel with it is a second fold, which divides into two above the spinnerets. Connected with this second fold are two oblique folds, as shown in the figure of the female (pl. III, fig. 18). The ventral surface of the abdomen is partly covered by a large epigastric scute, which extends forward round the pedicle. The posterior margin of the scute is produced backward into two lobes, one on each side. Book-lungs are wanting. A pair of anterior tracheal spiracles are situated in the notches formed between the scute and its posterior lobes. A posterior median tracheal spiracle is also present and is situated immediately in front of the colulus, being partly concealed by the posterior margin of the chitinous ring, which surrounds the spinnerets. Behind the posterior lobes of the epigastric scute are two rounded sclerites, one on each side. A short distance in front of the mamillary ring is a transverse row of four small sclerites. In addition to these there are numerous small setigerous sclerites in the soft integument at the sides and on the ventral surface. Six spinnerets are present and a small colulus in front of them. The colulus is provided with two hairs.

Female

	mm.
Total length	1·0960
Length of cephalothorax	0·4795
Width of cephalothorax	0·3699
Length of abdomen	0·7809
Width of abdomen	0·6987

Leg.	Femur.	Patella.	Tibia.	Metatarsus.	Tarsus.	Total.
1	0·2877	0·1233	0·2055	0·1096	0·2466	0·9727
2	0·2603	0·1233	0·1781	0·0959	0·2192	0·8768
3	0·2329	0·1096	0·1507	0·0959	0·2192	0·8083
4	0·3014	0·1233	0·2466	0·1027	0·2329	1·0069

The female closely resembles the male. Only the following characters need be described.

Legs. The tarsi of the first pair of legs differ from those of the male in being straight and of normal shape. They are also without spines.

Palpi. Vestigial, being reduced to the coxa, maxillary lobe and a small tubercle-like projection on the outer surface of the coxa (pl. III, fig. 19).

Abdomen. The dorsal and epigastric scutes resemble those of the male. The spermathecal apertures have the form of a pair of circular openings a short distance in front of the posterior margin of the epigastric scute. Between the posterior lobes of the scute and immediately behind its posterior margin is a slender and slightly procurved sclerite (pl. III, fig. 20.) The form of the epigynum as seen in transparent preparations is shown in pl. III, fig. 21. Tracheal spiracles, colulus and spinnerets as in the male.

Locality. Tasmania: Mt. Wellington (3000 ft.). Six males and 12 females collected in moss during July and August, 1943.

Habits, Web, and *Egg-sac. Micropholcomma parmata* lives amongst moss growing on the surface of large rocks on the slopes of Mount Wellington. Both male and female specimens were collected under cold and damp conditions, when the mountain was partly covered with snow. Specimens kept amongst damp moss in small glass tubes in the laboratory and fed on minute Collembola lived for several months. They made small, irregular webs like those of the Theridiidae. Early in October two of the specimens made egg-sacs. These were formed of closely woven white silk and attached to the leaflets of the moss. They had the shape of a shallow pill-box the lid of which was slightly raised in the centre and produced into a flange round the margin (pl. III, fig. 22). One of the sacs measured 1·233 mm. in diameter and 0·550 mm. in height. From an egg-sac made on 11th October, 1943, two young spiders emerged on 7th December. One was a female and had vestigial palps no more developed than in the adult.

Micropholcomma mira, sp. n.

Male

	mm.
Total length	1·1919
Length of cephalothorax	0·4521
Width of cephalothorax	0·3973
Length of abdomen	0·8220
Width of abdomen	0·7124

Leg.	Femur.	Patella.	Tibia.	Metatarsus.	Tarsus.	Total.
1	0·3425	0·1370	0·2192	0·1233	0·2466	1·0686
2	0·3014	0·1370	0·1918	0·1096	0·2329	0·9727
3	0·2877	0·1301	0·1781	0·1233	0·2192	0·9384
4	0·3562	0·1370	0·2808	0·1370	0·2466	1·1576
Palp	0·0715	0·0924	0·0477	....	0·0805	0·2921

Colour. The ground colour is chestnut-brown. Carapace speckled with black and marked with a rectangular black pattern on its highest part. Faint, radiating lines in the position of the radial grooves. Sternum mottled with black and marked with triangular black patches pointing inwards from the margin. Labium suffused with black. Dorsal shield of abdomen finely speckled with black.

Carapace. Viewed from above, somewhat pyriform, narrowed and rounded in front, and with slightly sinuous lateral margins. Viewed from the side, high, steeply ascending from posterior margin and gently curved over the head region to the eyes. Its highest point lies above a line between the second coxae and is furnished with a pair of long, erect, stiff hairs, which curve forwards. In front of these hairs is a median longitudinal row of three shorter hairs. Radial grooves are faintly marked. Dorsal surface of head-region smooth, rest of the carapace finely granular (pl. IV, fig. 23).

Eyes. Eight, arranged in two rows. The posterior row is slightly longer than the anterior row. The eye-group occupies almost the full width of the head region. Viewed from above the posterior row appears straight and the front row recurved. Viewed from in front both rows appear procurved. The ratio of the eyes AME : ALE : PME : PLE = 9 : 14 : 11 : 14. The AME are separated from each other by 3/9 and from ALE by 2/9 of their diameter. The lateral eyes are contiguous. The PME are separated from each other by 8/9 and from PLE by 6/9 of the diameter of AME. The median ocular quadrangle is wider behind than in front in ratio 31 : 22. Its length is shorter than its posterior width in ratio 28 : 31. The height of the clypeus in front of AME is equal to 30/9 of the diameter of AME. A single hair below AME and a pair of hairs on each side below ALE.

Chelicerae. Stout and strong. Lateral condyles and stridulating ridges lacking. Inner margins oblique. Two small teeth on promargin, one on retromargin. A long bristle and two short spines in a row in front of promargin. A light scopula consisting of five barbed hairs in an oblique row is situated behind the retromargin. Fang moderately long and curved. There are a few long hairs on the front of the chelicerae.

Maxillae. Triangular, converging in front of labium. Provided with a light apical scopula and a well developed serrula.

Labium. Immobile. Much wider than long. Slightly emarginate in front. Provided with five hairs in a transverse row.

Sternum. Convex, cordiform, and truncate behind. Margin rebordered. Wider than long in ratio 22 : 20. Clothed with a few long hairs. Fourth coxae widely separated (pl. IV, fig. 24).

Legs. 4.1.2.3. Tarsi about twice the length of the metatarsi. Hairs simple, except on the ventral side of the tarsi, where they are barbed. Spines are wanting. Two trichobothria on the first tibiae, one on the second, two on the third, and three on the fourth. No trichobothria on other segments. The prolateral surface of the first femora is furnished with a group of small denticles or granules near the base (pl. IV, fig. 25). The granules extend along about 1/3 of the length of the segment. All the patellae have a distinct bulge on the retrolateral side. Scopulae and claw-tufts absent. Three tarsal claws are present. In the first and second tarsi the upper claws have four teeth and in the third and fourth tarsi three teeth. The lower claw has a single tooth.

Palpi. Very small. Not as long as the first femora. The patella is the longest segment and has a curved, pointed apophysis on the retrolateral side at the apex. The tibia is short and expanded distally. It is inserted on the prolateral side of the patella. Tarsus rounded and spoon-shaped. The genital bulb is rounded and the embolus arises on its surface and makes one complete turn (pl. IV, fig. 26). The retrolateral edge of the cymbium is furnished with about four long hairs, which project over the bulb. Two similar hairs are present on the retrolateral side of the tibia.

Abdomen. Cordiform and somewhat sharply narrowed behind. Dorsal surface, except the narrowed posterior part and a small lateral margin, is covered by a hard scute. The surface of the scute is smooth and clothed with fine hairs. The integument below the lateral and posterior margins of the scute forms a continuous horizontal fold, which, round the posterior end, is reinforced by a long, narrow sclerite. On each side near the front of the abdomen the horizontal fold gives rise to two oblique folds which pass downwards towards the spinnerets. The grooves between the folds are occupied by small sclerites in a row. On the

ventral surface there is a large epigastric scute, which extends forward round the pedicle and is produced backwards into two lobes as in the preceding species. On each side of the epigastric scute is a longitudinal row of small sclerites, which extends backwards to join a transverse row of four sclerites in front of the large chitinous ring surrounding the spinnerets. Book-lungs are absent. A pair of anterior tracheal spiracles open in the notches formed between the epigastric scute and its posterior lobes. A single median posterior tracheal spiracle opens in front of the spinnerets on the posterior margin of the chitinous ring. Six spinnerets and a colulus are present. The anterior spinnerets are the largest of the group. Each is provided with four long conical spinning tubes. The middle spinnerets are small and hidden by the others. The posterior spinnerets are provided with peculiar, coarse, black, sinuous setae. These setae are minutely barbed (pl. IV, fig. 27).

Female

	mm.
Total length	1·2741
Length of cephalothorax	0·4932
Width of cephalothorax	0·4247
Length of abdomen	1·0275
Width of abdomen	0·7946

Leg.	Femur.	Patella.	Tibia.	Metatarsus.	Tarsus.	Total.
1	0·3014	0·1370	0·2055	0·1233	0·2466	1·0138
2	0·2603	0·1370	0·1918	0·1096	0·2329	0·9316
3	0·2466	0·1370	0·1918	0·0959	0·2329	0·9042
4	0·3425	0·1507	0·2877	0·1370	0·2603	1·1782

The female resembles the male in coloration but differs somewhat in shape. The cephalothorax is wider in front. The abdomen is more oval and not so strongly narrowed behind. The dorsal scute, instead of being smooth, is coarsely pitted. It is also more extensive than in the male (pl. IV, fig. 28).

Eyes. Arranged as in the male. Ratio of eyes AME : ALE : PME : PLE = 10 : 15 : 13 : 15. AME separated from each other by 3/10 and from ALE by 2/10 of their diameter. The lateral eyes are contiguous. PME separated from each other by a space equal to the diameter of AME, and by half this distance from PLE. The median ocular quadrangle is wider behind than in front in ratio 36 : 23. Its length is less than its posterior width in ratio 28 : 36. Height of clypeus in front of AME is three times the diameter of AME.

Chelicerae, maxillae, labium, sternum and *legs* resemble those of the male.

Palpi. Vestigial, consisting of the coxa, maxillary lobe, and a small conical projection on the outer side of the coxa. The projection carries two or three hairs (pl. IV, fig. 29).

Abdomen. Broadly ovoid. Dorsal surface almost completely covered by a leathery chitinous scute. Incorporated in the scute are several submarginal sclerites as shown in pl. IV, fig. 28. The scute is clothed with fine hairs and has a coarsely pitted appearance. The integument at the sides of the abdomen is folded as in the male, but there is no narrow sclerite in the posterior portion of the horizontal fold. The epigastric scute has the same form as in the male but is perforated by the two spermathecal apertures, one on each side, slightly in front of the posterior margin of the scute (pl. IV, fig. 30). The tracheal spiracles are situated as in the male. A colulus and six spinnerets are present. They are surrounded by a chitinous ring, which is not as large as in the male. The coarse

barbed setae on the posterior spinnerets of the male are represented by more slender setae in the female. The form of the epigynum as seen in transparent preparations is shown in pl. IV, fig. 31.

Locality. Tasmania: New Town. 10 males and 14 females collected from moss in a garden lawn, 23rd December, 1943.

APPENDIX

The Respiratory Systems of Chasmocephalon and Micropholcomma

The respiratory systems of *Chasmocephalon minutum* sp. n. and of the four species of *Micropholcomma* described above were examined both in serial sections and in specimens treated with caustic potash solution.

In *Chasmocephalon minutum*, as in the undescribed species examined by Dr. Fage (1937, p. 97), book-lungs are absent. In place of book-lungs there is a pair of anterior tracheal spiracles, each of which opens into a short atrium. The two atria are quite independent, there being no transverse connecting tube between them. Each atrium supplies a number of tracheal tubes to both the cephalothorax and the abdomen (pl. V, fig. 32). About sixteen tubules pass through the petiolus into the cephalothorax and one tube enters each appendage. In transverse sections of the petiolus the tracheal tubules are seen to lie immediately below the mid-gut (pl. V, fig. 33). Posterior tracheal spiracles are absent. The heart has two pairs of ostia.

In the four species of *Micropholcomma* book-lungs are also absent. As previously mentioned there is a pair of anterior tracheal spiracles and also a single median posterior tracheal spiracle. Each anterior spiracle opens into a short atrium. The left and right atria are connected by a wide transverse tube situated immediately above the posterior margin of the epigastric scute. In front, each atrium gives rise to two pairs of stout tracheal tubes which curve forwards and upwards. The inner pair of tubes, on reaching the level of the petiolus, bend sharply towards the front and pass through the petiolus into the cephalothorax. The outer pair pass upwards and backwards, one on each side of the heart (pl. V, fig. 34). The pair of tubes which enter the cephalothorax are situated immediately above the mid-gut in the petiolus (pl. V, fig. 35). They pass forwards and lie one on each side of the sucking-stomach. Here each gives rise to a large number of smaller tubes supplying various parts of the cephalothorax. In addition to the two pairs of stout tracheal tubes given off anteriorly from the atria there are also numerous smaller tubes that arise laterally and supply parts of the abdomen.

The single median posterior tracheal spiracle in front of the colulus leads into a short atrium which gives rise to two pairs of small slender tubules. These are confined to the abdomen and do not enter the cephalothorax. The heart is quadrostiate.

Acknowledgments are made to the Trustees of the John Ralston Bequest under whose auspices the above work was carried out. I am also indebted to Mr. C. Oke for specimens and to Mr. S. Butler for literature.

References

Butler, L. S. G., 1932.—Studies in Australian Spiders, No. 2. *Proc. Roy. Soc. Victoria.* 44 (N.S.), Pt. II, 1932, pp. 103-117.

Crosby, C. R. and Bishop, S. C., 1927.—New Species of Erigoneae and Theridiidae. *Journ. N.Y. Entomol. Soc.*, XXXV, 1927, pp. 147-153, pls. XV and XVI.

Fage, L., 1937.—A propos de quelques nouvelles Araignées apneumones. *Bull. Soc. Zool. France*, LXII, 1937, pp. 93-106.

PLATE I

Chasmocephalon minutum, sp. n.

FIG. 1.—Lateral view of male. Legs and palpi omitted.

FIG. 2.—Front view of eyes and clypeus of male.

FIG. 3.—Front view of right chelicera of male.

FIG. 4.—Retrolateral view of right palpus of male.

FIG. 5.—Prolateral view of right palpus of male.

FIG. 6.—Ventral view of abdomen of male. *t.s.* right tracheal spiracle.

FIG. 7.—Posterior half of epigastric scute of female showing epigynum as seen in transparent preparations. *t.s.* right tracheal spiracle.

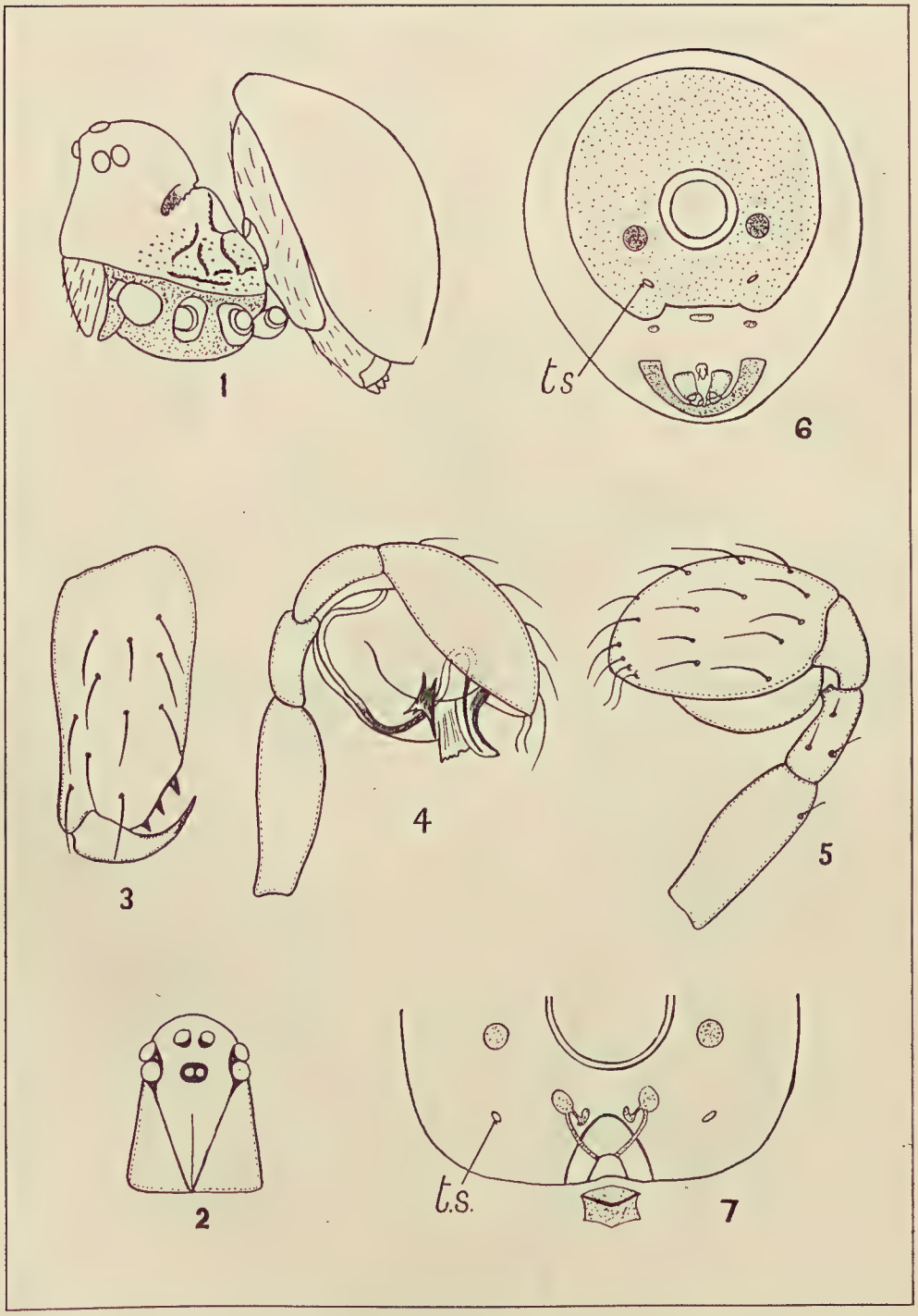

1
ts
6
3
4
5
2
t.s.
7

PLATE II

Micropholcomma caeligenus Crosby and Bishop

FIG. 8.—Front view of left maxilla of female showing the vestigial palpus. Hairs omitted.

FIG. 9.—Ventral view of abdomen of female.

FIG. 10.—Posterior part of epigastric scute of female showing epigynum as seen in transparent preparations.

Micropholcomma bryophila (Butler)

FIG. 11.—Retrolateral view of right palpus of male.

FIG. 12.—Retrolateral view of left palpus of female showing reduction in number of segments.

FIG. 13.—Ventral view of abdomen of female.

FIG. 14.—Posterior part of epigastric scute of female showing epigynum as seen in transparent preparations.

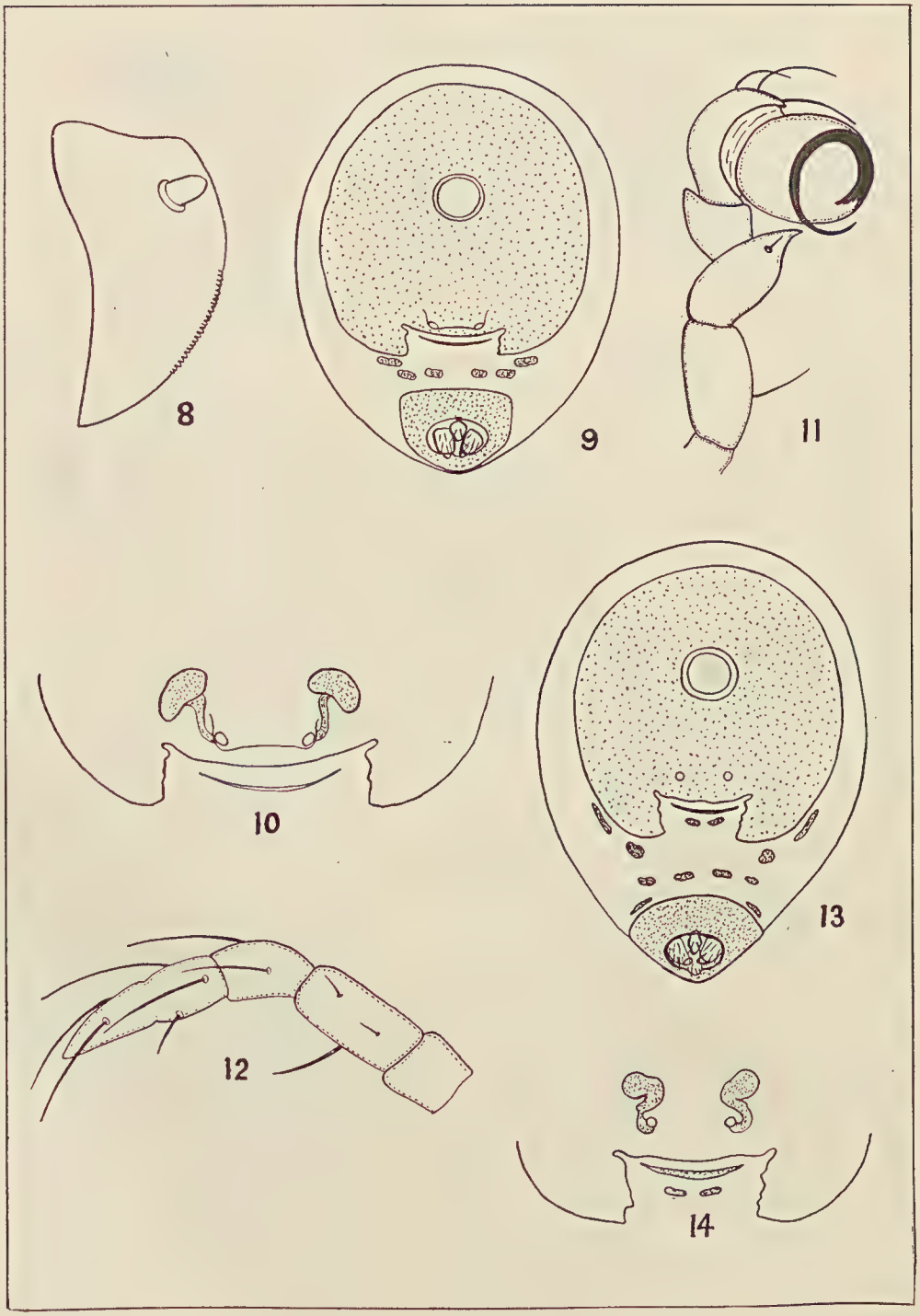

8
9
11
10
13
12
14

PLATE III

Micropholcomma parmata, sp. n.

FIG. 15.—Front view of eyes and chelicerae of male.

FIG. 16.—Prolateral view of left front leg of male showing the sinuous tarsus.

FIG. 17.—Retrolateral view of left palpus of male.

FIG. 18.—Lateral view of female. Legs omitted.

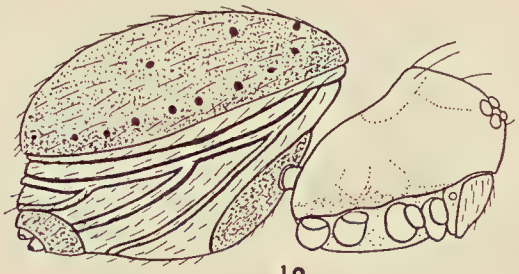
FIG. 19.—Front view of left maxilla of female showing vestigial palpus.

FIG. 20.—Ventral view of abdomen of female.

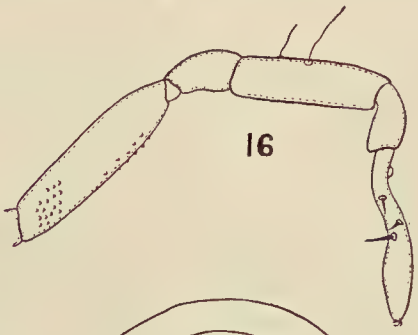
FIG. 21.—Posterior part of epigastric scute of female showing epigynum as seen in transparent preparations.

FIG. 22.—Egg-sac attached to a piece of moss.

15



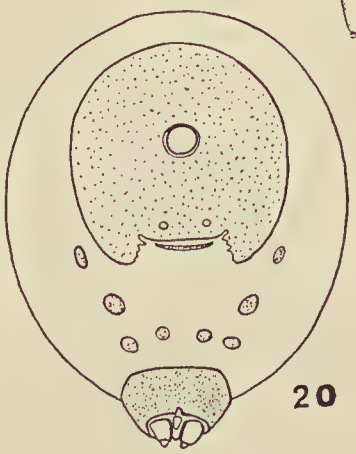
18



16

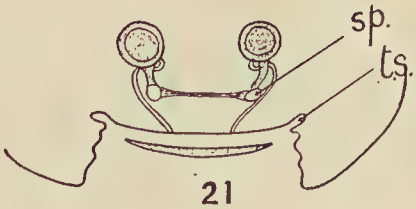
17

19



20

22



21

PLATE IV

Micropholcomma mira, sp. n.

FIG. 23.—Dorsal view of male. Left legs omitted.

FIG. 24.—Ventral view of sternum and abdomen of male.

FIG. 25.—Prolateral view of left front leg of male.

FIG. 26.—Retrolateral view of left palpus of male.

FIG. 27.—Ventral view of posterior spinnerets showing the large sinuous spines.

FIG. 28.—Dorsal view of female. Legs omitted.

FIG. 29.—Front view of left maxilla of female showing vestigial palpus.

FIG. 30.—Ventral view of abdomen of female.

FIG. 31.—Posterior part of epigastric scute of female showing epigynum as seen in transparent preparations.

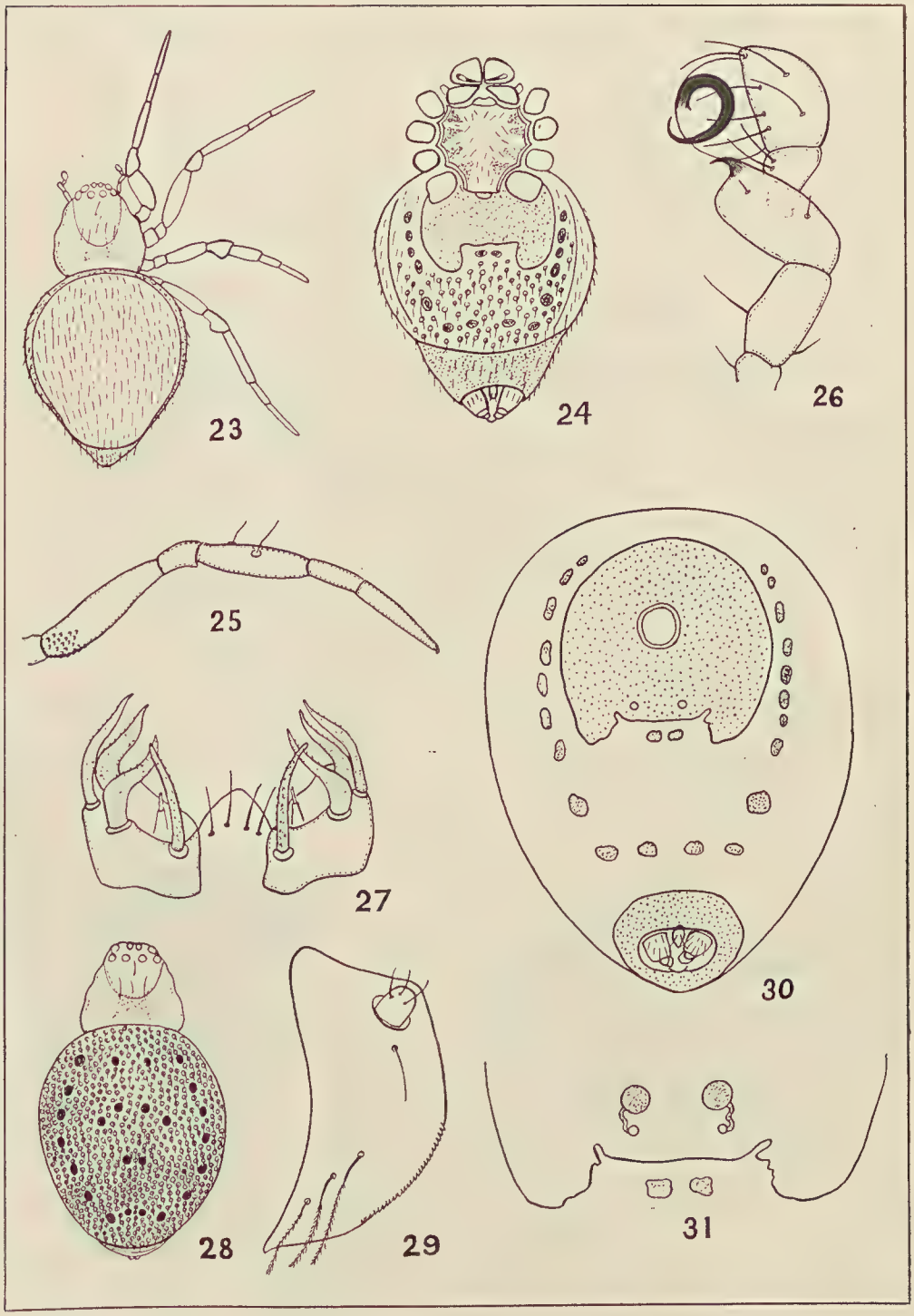

23
24
26
25
27
30
28
29
31

PLATE V

Chasmocephalon

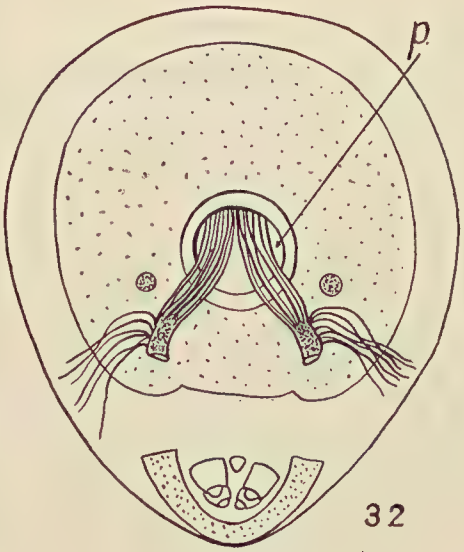
FIG. 32.—Diagram to illustrate the tracheal system in the abdomen. *p.* foramen in epigastric scute for petiolus.

FIG. 33.—Part of a transverse section through the petiolus showing the tracheal tubes situated below the gut.

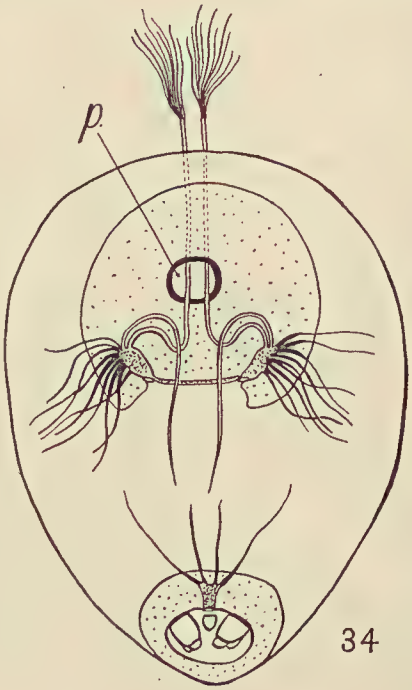
Microphalcomma

FIG. 34.—Diagram to illustrate the tracheal system in the abdomen. *p.* foramen in epigastric scute for petiolus.

FIG. 35.—Part of a transverse section through the petiolus showing the two stout tracheal tubes situated above the gut.



32



34

33

35

Pap. & Proc. Roy. Soc. Tasmania, 1943 (15th December, 1944.)

Variations in Pultenaea juniperina Labill.

By

Winifred M. Curtis

(Read 25th November, 1942)

Plate VI

The genus *Pultenaea* Smith, endemic in Australia, is one of the largest genera of Australian legumes. Seventy-five species were recognised by Bentham (1864), and of these, fourteen are recorded from Tasmania.

Pultenaea juniperina Labill. is abundant throughout Tasmania, being found in a wide range of habitats at all altitudes between sea-level and 4000 ft. The plant, which forms an erect much branched shrub several feet in height, bears simple pungent, evergreen leaves ¼ to ½ an inch in length, each leaf spreading approximately at a right angle from a short petiole, which is adpressed to the stem. Small stipules are present.

There is a considerable degree of variation in the shape of the leaves of *P. juniperina*, the range in shape being from linear to narrow ovate. The leaves are concave, having incurved margins. One wide-leaved and distinctive form of the plant was distinguished by Bentham as *P. juniperina* var. *latifolia*. This form had previously been raised to specific rank by Graham, who described it as *P. cordata*. Although the general appearance of the latter plant is markedly different from that of *P. juniperina* Labill. this difference is due entirely to the leaves, which are broad, often cordate, at the base and closely crowded on the stems (fig. 5). There are no essential differences in the structure or form of the flowers. Hooker (1860), while recording the two species *P. juniperina* Labill. and *P. cordata* Grah. expressed the opinion that the latter might prove to be a variety of the former—the view adopted by Bentham.

In the present study of the taxonomic status of *P. juniperina* Labill. var. *latifolia* Benth., the chromosome complement of this plant was compared with that of the type. Counts of the somatic number of chromosomes were made from mitotic figures in root tips. The roots were taken from the plant illustrated in fig. 5, and from seedlings obtained from the plan shown in fig. 4. Root tips were fixed in the Craf modification of Navashin's solution, sectioned at 12μ and stained in Haidenhain's iron-alum haematoxylin. The chromosome complements at somatic mitosis are illustrated in figs 6, 7: thirty-six chromosomes are found in *P. juniperina* Labill. and twenty-seven in *P. juniperina* Labill. var. *latifolia* Benth.

These results suggest a basic chromosome number of nine, the specimens of *P. juniperina* examined, being tetraploid, and the variety *latifolia*, triploid.

This hypothesis is consistent with observations on the method of reproduction of the plants. While the flowers of *P. juniperina* form abundant viable pollen

and set seed from which plants establish readily, in the variety *latifolia* all the flowers examined have contained only abortive and shrivelled pollen grains. The latter plant spreads vegetatively, sending out vigorous underground stems. *P. juniperina* may also spread by similar vegetative means as well as by the production of seeds.

Several questions raised by these observations can be answered only through further investigations. *P. juniperina* var. *latifolia*, though less widespread in Tasmania than the type, is locally abundant in widely separated areas. The possibility of the occasional production of seed by this plant cannot be excluded. However, it is conceivable that a study of the chromosome complements of a number of specimens representative of the range of variation normally found in *P. juniperina* Labill. may provide a clue to the origin of the distinctive variety *latifolia*.

This problem is one that arose during the course of investigations carried out whilst in receipt of a Commonwealth Research Grant. I should like to express my thanks to Dr. H. D. Gordon for his advice.

References

Bentham, G., 1864.—*Flora Australiensis.* Vol. II. London.

Hooker, J. D., 1860.—*The Botany of the Antarctic Voyage.* Part III, Vol. I. London.

PLATE VI

Figs 1 to 4.—*P. juniperina* Labill. Flowers × 2.

Fig. 5.—*P. juniperina* var. *latifolia.* Branch × 2.

Figs 6, 7.—Diagrams made with camera lucida × 2,500. 6, *P. juniperina* Labill. 7, *P. juniperina* Labill. var. *latifolia.*

1
2
3
4
5
6
7

The Royal Society of Tasmania, 1843-1943

By

J. Somerville

Plates VII-IX

The Royal Society of Tasmania was founded on 14th October, 1843, at a meeting convened by the Lieutenant-Governor Sir J. E. Eardley-Wilmot, Bart., and on the occasion of the centenary of this event it may be of interest to review the development of the Society and its honourable record of scientific achievement.(1)

Though an account of earlier institutions and scientific bodies has been given by Piesse (1913), the important part taken by Governor Arthur in launching and maintaining scientific societies should be recalled. The Mechanics Institute (1826) and the V.D.L. Scientific Society (1829) both flourished during Arthur's regime, and the latter Society, as well as being occupied with papers and discussions, also established a Museum.

The scientific interests of the colony were further stimulated by Sir John Franklin, who in 1838 formed the Tasmanian Society, which continued its meetings and publications till 1849. Thus, after the foundation of the present Royal Society in 1843 by Sir J. E. Eardley-Wilmot, the colony maintained two scientific societies for several years. However, as the Governor's patronage was given to the Royal Society, it is not surprising that the membership of the sister Society decreased until finally, in 1849, the remnant joined the Royal Society of V.D.L.

Apart from its intimate association with these earlier scientific bodies in Van Diemen's Land dating from 1821, the Royal Society claims to be the oldest scientific society in Australasia, as it has existed since 1843 without a break in its meetings and has an uninterrupted series of publications since 1844.

---

(1) The history of the Society is given in part in the following papers:—

Sir Robert Hamilton.—Presidential address at the Hobart meeting of the Australian Association for the Advancement of Science, 1892.

J. H. Maiden.—Records of the Tasmanian Botanists. *Papers and Proceedings of the Royal Society of Tasmania*, 1909, pp. 9-29.

A. Morton.—History of the Royal Society of Tasmania. *Papers and Proceedings of the Royal Society of Tasmania*, 1894-1895, Appendix, pp. 1-6. 6 plates.

A. Morton.—Some account of the Work and Workers of the Tasmanian Society and the Royal Society of Tasmania from the year 1840 to the close of 1900. *Papers and Proceedings of the Royal Society of Tasmania*, 1900-1901, pp. 109-126.

F. Noetling.—Notes on the Publications of the Royal Society of Tasmania. *Papers and Proceedings of the Royal Society of Tasmania*, 1910, pp. 223-230.

E. L. Piesse.—The foundation and early work of the Society with some account of other institutions of early Hobart. *Papers and Proceedings of the Royal Society of Tasmania*, 1913, pp. 117-166, plates xiii-xx.

The name of the Society has been changed on several occasions. At the inaugural meeting it was decided to call the society 'The Botanical and Horticultural Society of Van Diemen's Land'. On 12th September, 1844, however, when Queen Victoria consented to become patron of the Society, the name was changed to 'The Royal Society of Van Diemen's Land for Horticulture, Botany, and the Advancement of Science'. The constitution was approved, the Gardens in the Domain were placed at the disposal of members, and an annual grant of £400 was confirmed.

By an Act of the Legislative Council in 1854, the property of the Royal Society was vested in Trustees, and in 1855 the name was altered to 'The Royal Society of Tasmania for Horticulture, Botany, and the Advancement of Science'.

When the Act of 1854 was repealed in 1911, the Royal Society Act (2 Geo. V. No. 47) adopted the shorter title of 'The Royal Society of Tasmania', and, by the same Act, the Society was created a body corporate, with powers conferred upon it in regard to (1) holding property, (2) litigation, and (3) making and altering rules.

Aims and Objects of the Royal Society of Tasmania

According to the original rules in 1843, the leading objects of the Society were 'to develop the physical character of the Island, and illustrate its natural history and productions'. This definition was retained till 1907, when new rules declared that 'the objects of the Society are the prosecution of the study of Science in its various branches, and more especially the development of a knowledge of the physical characters and natural history of Tasmania and the neighbouring States'. This was re-embodied in the new rules made under the Royal Society of Tasmania Act, 1911, but in 1914, when it was deemed advisable to broaden the scope of the Society's aims, Rule 1 was altered to read 'The object of the Society is the advancement of knowledge', and this rule is still in force.

Meeting Places of the Royal Society of Tasmania

The inaugural meeting was held on 14th October, 1843, in the library at Government House, Macquarie Street, and a further meeting was held at Government House in the same month.

1844-46. 'The meetings were held in town, frequently at the office of the Colonial Treasurer'[1] (Hon. P. Fraser).

1846-47. The Society met in the house of the Secretary, at the Botanical Gardens. This was built in 1829 and is now occupied by the Superintendent of the Gardens.

1848-52. The Governor, Sir William Denison, placed at the Society's disposal the large Committee Room at the Legislative Council Chambers and later allowed the use of his own ante-room for the collections and the library. This room may be regarded as the first home of the Museum and Library. Towards the end of this period the limited accommodation afforded by their quarters began to exercise the Council.

In 1852 the Society moved to Harrington Street, opposite St. Joseph's Church. There has been some misconception as to the precise building to which the Society moved in 1852. At that time there was a house (Conara) at the corner of Harrington and Macquarie Streets with its entrance in the latter. Adjoining it,

[1] E. L. Piesse, loc. cit., p. 145.

but separate from it, was a second house situated wholly in Harrington Street. It was this latter house which was occupied by the Society. Both houses were owned by George Whitcombe. In 1852 G. A. Anstey resided in 'Conara' and he was followed by Miss Emily Lavers, whose name appears on the ratepayers' roll for several years, whilst at the same time the Royal Society occupied the Harrington Street building which had been erected in 1847. The two houses were converted into a single building during the occupancy of the Metropolitan Drainage Board at some time during the period 1904-1907. To-day, this building, with its main entrance in Macquarie-Street, is occupied by Dr. V. R. Ratten.

The Society remained in its Harrington Street home until the end of 1862, when it moved into the present Museum which had been built through the Society's efforts. During the Harrington Street period the Council was constantly faced with the problem of the need for more commodious quarters to house the growing Museum and Library. The Government viewed favourably the Society's need for a permanent building, and sites in (1) Fitzroy Crescent, (2) Murray Street (on the site of the old gaol), (3) Collins Street, (4) Franklin Square, (5) new Government buildings, Murray Street, were considered. Finally, the site[1] of the present Museum was given to the Society in 1860.

The total cost of the building with fittings was about £4800, of which members subscribed about one-third.

1863-1902. Until 1902, the room which is now the Director's Office housed the Society's library and was generally used for the meetings of the Society. Special meetings were held in the Art Gallery—after 1889; also the monthly meetings 1900-1901.

1902-1930. The room leading out of the entrance hall at the foot of the main staircase was used by the Society until 1930, when the removal to the present room was effected. The latter is now proving to be inadequate and additional accommodation will have to be made available when the much needed new Museum wing has been provided.

Activities of the Royal Society of Tasmania

The Society's main activities during its history may be given briefly as follows:—

1. Development of the Botanical Gardens.
2. Development and growth of the Museum.
3. Development and growth of the Library.
4. The Society's monthly meetings.
5. Branches and achievements.
6. Publication of Papers read before the Society and of the Proceedings of the Society.
7. Activities other than scientific.

---

(1) The historical associations of the site should not be forgotten. When Collins landed, 20th February, 1804, and tents were pitched, Knopwood's tent was on the spot where the Museum steps and entrance doors now stand. Later, the block of land formed that portion of the Government House grounds on which was situated the Private Secretary's cottage.

1. The Botanical Gardens

The present Botanical Gardens were originally part of 50 acres granted by Governor Collins in 1806 or 1807 to John Hangan, from whom the land was purchased by R. W. Loane in 1813. His title was not recognised by Governor Sorell who, assuming the land, established thereon the Government Gardens or Colonial Gardens in 1818 (Piesse, 1913).

In 1828, Governor Arthur having decided to develop the grounds as botanical gardens and to specialize in native flora appointed a Superintendent (William Davidson) 'at a salary of £100 per annum with rations and a house to live in'. Accordingly, the present stone house, which is still in use, was built and occupied by Davidson, 1829. The wall (Piesse, p. 122) with its fireplaces and flues may still be seen, and the original gateway where the visitor's book was signed now stands close to the entrance to the present Herbarium.

Up to the end of Governor Franklin's regime, the Gardens were maintained from public funds for the sole use of the Lieutenant-Governor. At the appointment of Lieutenant-Governor Eardley-Wilmot, however, the Secretary of State decided that the Colonial Gardens should no longer be maintained from public funds. The new Governor then proposed to hand over the Gardens to the newly-formed Society, with an allowance of £400 a year from public funds for their maintenance. On 1st January, 1844, the Society entered into possession. Since Horticulture was one of the original objectives of the Royal Society it followed that, during the early years the Gardens absorbed most of the energies of the Society. Even when, in the early sixties, the maintenance of the Gardens involved a serious financial burden, and the Council found itself in straitened circumstances, the Gardens were not allowed to suffer. Considerable popularity was gradually achieved as may be seen by the numbers who signed the visitors' book.

1847	2,287
1856	13,251
1863	20,488
1885	67,000

The Society's control continued until 1885, when the Council of the Royal Society handed over its interests in the Botanical Gardens and Museum to the State Government, which placed the administration in the hands of a Board of Trustees and accordingly, until 1911, the Curator of the Museum was also Curator of the Botanical Gardens. Since 1911, however, the Superintendent of the Gardens has been the officer in charge, whilst the Curator of the Museum has acted as Secretary to the Board. The representation of the Society on the Board will be referred to in another section of this paper.

Considerable alterations and improvements have been effected since 1900. The teahouse was built and opened in 1908, the bush house in 1910. Radical changes planned by the Trustees in 1932 were at first viewed with grave concern by a section of the public. Further improvements were planned in 1936 *et seq.* and the present condition of the Gardens with the spacious lawns, extensive vistas and the fine Conservatory, built with money provided by the late Hon. L. M. Shoobridge, the Tasmanian Government, and the City Council, provided ample evidence of the wisdom of the policy pursued by the Trustees. It is to the late Hon. L. M. Shoobridge that the main credit for the Conservatory should be given. It was his conception, and without his enthusiasm and perserverance it is doubtful whether a Conservatory would ever have been built at the Gardens. Mr. Shoobridge offered

to contribute a sum of money provided that the Government and the Hobart City Council contributed a like amount. It is only right to add that, once the Government became involved in the scheme, they spared no expense in providing labour and material to ensure the success of the project. The Conservatory, which is regarded as one of the finest in the Commonwealth was designed by the Superintendent, I. V. Thornicroft.

Superintendents of the Botanical Gardens—

William Davidson	1828-1834
Martin Tobin	1834-1840
J. Herbertson	1841-1844
— Grant	1844-1845
J. Dickenson	1845
F. W. Newman	1845-1859
Francis Abbott, Junr.	1859-1903
John Wardman	1911-1932
Leonard Rodway	1928-1932—Director
Clive Lord	1932-1933—Acting Officer in Charge
Olive Rodway	1932-1935—Acting Assistant Secretary
Ira D. Thornicroft	1936- —Superintendent

Residence of the Superintendent. As previously stated, a stone house was built for the Superintendent in 1829 and was occupied by W. Davidson and his successors, Tobin and Herbertson.

In 1843, however, when Lieutenant-Governor Eardley-Wilmot handed the gardens over to the newly-formed Royal Society of V.D.L., the Council decided that their Secretary should reside in the house hitherto occupied by the Superintendent and that for the latter a cottage should be built. In 1845, the Council proposed to fit up the rooms of the stone house lately occupied by the Secretary as a Museum and Reading-room, and meetings of the Society were held there, 1846-47. The house not being required by Dr. Lillie nor by succeeding secretaries, the Superintendent (W. Newman) in 1847 was allowed temporary occupation, and this privilege was also accorded to Francis Abbott. In 1887, the Trustees of the Tasmanian Museum and Botanical Gardens were granted the Private Secretary's house (present Government House grounds) for the use of the Superintendent, Francis Abbott, who occupied this house till his death in 1903. From 1887 till 1911, the stone house was used partly as a seed store and as the residence of the foreman, but since 1911, the occupants have been—

John Wardman	1911-1932
L. Rodway	1932-1935
I. V. Thornicroft	1936-

2. The Museum

The first rules of the Society, which were adopted on 28th October, 1843, provided for the establishment of a Museum. Specimens soon came into the possession of the Society, both by gift and purchase, and a serious problem which exercised the Council in the early days was the provision of suitable quarters to house both Museum and Library. As already stated, the Society had two moves before it acquired its present home, viz., to Parliament House and to Harrington Street.

The growth of the Museum collections and the progress made by the Botanical Gardens was such that by 1885 they had attained the position of national institutions. In that year, the Society relinquished control of these two bodies and their administration was vested by the Government in a Board of Trustees, six of whom were members of, and elected by, the Council of the Royal Society, five were officials appointed by the Government, and one, the Crown Trustee, was nominated by the Governor. An amendment to the Tasmanian Museum and Botanical Gardens Act, 1885, passed in 1926, reduced the number to seven, viz., six members from the Council of the Royal Society, and one Crown Trustee. This section was repealed in 1938, and the clause amended as follows: 'Five trustees were to be elected by the Council of the Royal Society, two to be appointed by the Government, and two to be appointed annually by the Hobart City Council. A third amendment, in 1939, changed the representation to two Council nominees, five who are appointed by the Government and two annually by the Hobart City Council. When this amendment was passed in 1939, some members of the Society viewed with considerable apprehension the reduction in the Society's representation on the Board of Trustees, but in spite of this change the two institutions remain united in aims and service. In actual fact, four of the five Government Trustees are members of the Royal Society. The Government has taken a liberal view of its obligations to both institutions and has afforded greater financial assistance to them than at any previous period in their history.

The Museum, when erected in 1863, consisted of the four rooms at the corner of Argyle and Macquarie Streets, the two galleries parallel to Macquarie Street, and the entrance hall and stairs. The 1886 additions, which cost £3000, were the two Argyle Street rooms on the right of the entrance, and these were opened by Sir Robert Hamilton in 1888. By 1900, additional space was again an immediate necessity which was met by the vote of £4000 which was passed during the Parliamentary session of that year. The new portion faced the lane and consisted of two rooms, the present Library and Art Gallery, of which the front portion was built of stone from Brighton and Waterworks quarries. At the same time the open court between the old and new wings, now the Zoological Gallery, was enclosed and roofed. The opening of these new additions in 1902 represents the Museum as it is to-day. Though the building has remained unaltered since 1902, that has not been so in regard to its possessions. So numerous and valuable were the accessions that suitable accommodation again provided a serious problem by 1913, when the Trustees of the Museum and the Council of the Royal Society applied to the Government for an extension of the Museum buildings. The application was favourably considered, but the War 1914-18 prevented the fulfilment of the proposed assistance. A further application for extension of building and also for an increased grant was made in 1919, but funds were not available, though an additional vote of £100 for the Gardens was obtained.

If the position were acute in 1913, it is evident that the continued progress of the Museum has since raised it to one of major importance. With a full appreciation of the difficulties facing the Trustees, the present Government, after consideration of alternative schemes, voted the sum of £11,000 in 1940 for the proposed new wing, the erection of which has necessarily been postponed for the duration of the war. Though faced with these limiting conditions of accommodation, the Trustees, however, have resolutely adopted a policy of progressive development, in keeping with modern Museum methods, in regard to reorganization and arrangement of exhibits, as is evident from the new habitat groups, historical gallery, etc. The Society, therefore, may view with pride the Museum which to-day occupies an

important position in the educational, cultural. and scientific life of the community. The Museum has been fortunate in its Curators and Directors, who have devoted themselves wholeheartedly to its service and progress. The title 'Director' replaced that of 'Curator' in 1922.

It has been thought desirable to direct attention to the development of the Museum and Gardens after the Society relinquished control of these institutions, since the close association between the Museum and Botanical Gardens on the one hand and the Society on the other did not cease with the 1885 Act. This was particularly the case with the Museum, which, unlike the Botanical Gardens, must be regarded in every respect as the child of the Society. It is not too much to say that, since 1885, the development of both the Society and the Tasmanian Museum have been just as closely linked as in the earlier days when the Museum was directly administered by the Society. This close association owes much to the happy circumstances that since 1885, with the exception of one or two short breaks, the administrative head of the Museum has also been Secretary of the Royal Society. Under the Act of 1885, the Society retained the right of exclusive possession of sufficient rooms in the Museum for the safe custody of its library and for all other purposes connected with the Society's activities. Though nearly sixty years have elapsed since the Museum was first administered by a Board of Trustees, it would be difficult to lay down a line of demarcation between the functions and activities of the two institutions. As the years have passed, the parent has perhaps become more dependent upon its child but, whatever service the Museum may have rendered to the Society, the Museum Trustees have recognized the historic part which the Society played, in very difficult circumstances, towards the creation of the Museum and its establishment on a firm foundation. The Library has been of inestimable value to the scientific workers in the Museum and for this, as well as for other reasons, the association of the two institutions has been most vital. In this year of the Centenary it is unthinkable that a day should ever come when the close bond which exists between the two bodies should ever be broken.

Curators of the Museum and Art Gallery—

— Whiting	1862
Thos. Roblin	1862-1883
Alex Morton	1883-1907
Robert Hall	1908-1912
T. Thompson Flynn, Hon. Curator	1912-1913
G. H. Hardy, Assistant Curator	1913-1917
T. Thompson Flynn, Hon. Curator	1916-1918
Clive E. Lord, Assistant Curator	1918
„ Curator	1919-1922
„ Director	1922-1933
A. N. Lewis, Hon. Director	1931
Joseph Pearson, Director	1934-

The Tasmanian Museum Cottage

Reference has been made to the Private Secretary's cottage[1] in the original Government House grounds on the block of land given to the Royal Society in 1862.

A private house had been erected on this block of Crown land. After passing through several hands, it was rented by the Commissariat Department as a grain store in 1817. Two years later resumption was proposed by Sorell and compensation paid to the owners, Palmer & Co. of Calcutta (H.R.A. III. III, p. 13).

Ross in 1831 states that 'several alterations and additions had been made to the old Commissariat store near Government House, converting it into a neat and convenient cottage residence for the Private Secretary, W. T. Parramore'. It was the residence of the successive Private Secretaries until 1858, when the new Government House and grounds were occupied by Sir H. E. Fox Young.

When no longer required by the Governor, the cottage was used as an office by the Public Works Department, and finally in 1871 was given to the Tasmanian Museum Trustees as a residence for the Curator (Thos. Roblin). Alex Morton was the next occupant 1883-1890, but when a Government cottage on the Domain was made available for Morton in 1890, the caretaker, John Arnold, entered into possession of the Museum cottage.

3. The Library

Provision for the establishment of a Library was made in the original rules, but in the early years the Library was regarded as an auxiliary only, though an indispensable one, to the Museum. The first book, 'Loudon's Encyclopaedia of Plants', was purchased in 1846, and by 1849, the Library contained 250 volumes. On the 1852 balance-sheet, the sum of £115 9s. 7d. is listed for 'books to illustrate the contents of the Museum', and similar amounts occur in subsequent years. Among the treasures thus obtained are Gould's (1) Birds of Asia, (2) Birds of Australia, Hooker's Flora of New Zealand, etc.

A catalogue was published in 1850 which lists 329 books and pamphlets, a second followed in 1856, whilst a third was compiled by A. Morton in 1885. The annual report in 1913 records the number of books and pamphlets as about 9000 and further states that the Society's Library had long overgrown the accommodation provided. Not only was there no shelving in the Library Room for many of the books, but hundreds of volumes were distributed in other rooms of the Museum, in the basement, and in cupboards. More shelves were therefore added, and E. L. Piesse, Acting Hon. Secretary, undertook the task of compiling a catalogue and arranging the books. During his absence later, on war duties, L. Dechaineaux acted as Hon. Librarian until 1918, when Clive Lord was appointed to the dual position of Secretary and Librarian. The report, 1924, recorded 14,000 volumes for which space was urgently required. The need was met to some extent when, in 1930, the Library was moved from the Argyle Street room (now Tasmanian Ethnographical Room) to that in use at present. Catalogue revision was again in arrears owing to the rapid expansion of the Library, and for a time Miss A. E. Giblin assisted with this work.

---

[1] It may be recalled that after Sir J. E. Eardley-Wilmot was superseded as Administrator by C. J. Latrobe, 13th October, 1846, he retired to the Private Secretary's cottage, where he died 3rd February, 1847.

Another interesting link is associated with the Marquis of Salisbury who (then Lord Robert Cecil) was the guest of Sir William Denison in 1852. During his visit he became seriously ill and was removed to the cottage, then occupied by Lieutenant Andrew Clark, the Private Secretary, where he remained until his recovery two-three months later.

Upon the removal to the present room, Mrs. A. N. Lewis presented the carved blackwood scroll containing the Society's crest, now incorporated in the panel screen behind the President's chair.

In November, 1933, Mrs. Clive Lord was appointed Assistant Librarian, and the Council has recorded appreciation of the service she has rendered as assistant to Dr. J. Pearson, Secretary and Librarian, since 1934. The Library has been reorganized, additional shelves and three new bays have been installed, a new type of book cover for loose volumes has been introduced and a Card Index of Journals and Periodicals has been prepared, whilst an author and title index of text-books is in course of preparation. A detailed Card Index for Journals and Periodicals, including and extending Pitt's Catalogue List, is also being compiled.

At the close of 1942, the Library contained 20,366 volumes, and many reports and pamphlets. The number of institutions on the exchange list was 270, comprising 124 British, 54 American, and 92 from other parts of the world. Other journals, for which no exchange is required, are also received. The Library is fortunate in its possession of foreign material, and the journals are in demand by libraries of other States.

The Library is extensively used by members, students, scientific workers, and by various public departments. Thus the Society has reason to be proud of its Library, whose value to the State as a source of reference on scientific and historical matters is widely recognized.

4. Meetings of the Royal Society

In the early years, much business now dealt with by the Council was discussed at the monthly meetings, when lists of accessions to the Museum, Library, and Gardens were tabled and reports thereon discussed. This practice was continued even after 1885, particularly in connection with Museum exhibits. Not only were scientific papers read at these meetings, but also many subjects of a general nature related to matters of public interest or of importance in the development of the country occupied the attention of members. Numerous exhibits of the then comparatively little known natural history of the Island were presented at the meetings, and the resultant free discussion was a feature of the monthly reports, 1843-1907. Since that date, however, the main feature of the meeting has become more and more confined to the address on a scientific, historical, or literary topic, the discussion thereafter being subject to limitations if the lecture was not of a general nature. The effect of the dominant interests of members is evident when reviewing monthly abstracts, e.g., 1900-1912, when the Medical section was active, medical and general health topics occurred frequently. E. L. Piesse's active membership is reflected by the ordinary and special meetings which dealt with the constitution and rules of the Society, and later still, historical subjects held pride of place.

5A. Branches of the Society

Northern Branch. In 1853, at a meeting held at Franklin Lodge, a building in the Horticultural Society's Gardens (now the City Park), Launceston, a Northern Branch was formed, and among those present were W. Henty (chairman), R. C. Gunn, J. McArthur, C. Henty, W. Cleveland, and Rev. C. Price. In 1855, this branch received a grant of £63 17s. from the Society. Later the meetings were held in a room in the Public Buildings, but no record occurs in reports after 1860, though mentioned in Walch's Almanac until 1878.

Under the Royal Society Act, 1911, an addition to the rules in 1919 gave the Society power to create local branches, and accordingly in 1921, at a meeting in

the Mechanics Institute, the branch was reformed. W. R. Rolph was in the chair, and those present included G. H. Hogg, J. W. Bethune, C. W. Atkinson, Loftus Hills, F. Heyward, F. M. Littler, W. D. Reid, and J. R. Forward.

During the first year of its existence, the Branch not only held seven monthly meetings but also sponsored two public meetings in support of a proposal to establish a national reserve in the Cradle Mt.-Lake St. Clair region.

Since that date, it has been an active body, arousing considerable interest in historical records and relics and in Tasmanian ethnology. The work of some of the members will be mentioned under (1) 'Sections' and (2) 'Publications'. The Branch was also responsible for setting up in Royal Park, Launceston, a memorial pillar to mark the site of the observatory of A. B. Biggs, where what are now accepted as the official determinations of the latitude and longitude of Launceston were made. The telescope constructed and used by Biggs was bequeathed to the Royal Society in 1902. It was on loan to the University for many years, but in the absence of adequate facilities for accommodation and use, it was finally decided to return it to the executors. This was done in 1918.

Meetings were held at the Public Library (Mechanics Institute) until 1937 when, after the completion of the Fall-Hartnoll Memorial Wing at the Queen Victoria Museum and Art Gallery, the Launceston City Council gave permission to the Branch to make the Library and Lecture-room its permanent headquarters. With at last a settled home, the Branch has been organizing and extending its Library, and arrangements have been made with the parent Society for a selection of current scientific periodicals to be forwarded monthly.

As early as 1926, arrangements for the permanent retention in Launceston of historical material acquired by the Branch were made.

In 1930, there was initiated a custom, still (1943) in operation, of throwing the first meeting of the session open to the general public, and on that occasion subjects of popular interest are chosen. The move has met with marked success.

Branch Presidents—

G. W. Waterhouse	1921-1922
Hon. Tasman Shields	1923-1932
W. R. Rolph	1933-1934
A. L. Meston	1935-1937
F. J. Heyward	1938
F. Smithies	1939-1943

Branch Secretaries—

J. R. Forward	1921-1922
G. H. Halligan	1923-1924
R. S. Padman	1925-1929
E. O. G. Scott	1930-1931
A. L. Meston	1932
E. O. G. Scott	1933-1937
N. B. J. Plomley	1938
E. O. G. Scott	1939-1943

Other members who have taken an active part in forwarding the interests of the Branch are J. E. Heritage, R. O. Miller, R. A. Scott, D. V. Allen.

Midlands Branch. A Midlands Branch was established at Oatlands in 1920 as the result of the efforts of R. Kermode, but no reference to its meetings is contained in the Society's reports later than 1922.

5B. Achievements of the Society

The period 1843-1900 has been dealt with by Morton and by Maiden and, therefore, but a brief reference is needed. Papers by members were at first published in the Tasmanian Journal, notable contributors to which included John Gould, Professor Owen, Captain J. Ross, Count Strzelecki, Captain Sturt. This journal ceased publication in January, 1849, and Vol. I, Part I of the Papers and Proceedings of the Royal Society of Van Diemen's Land was published in May, 1849. The subjects of meteorology, zoology, botany, geology and matters of general interest, such as the weather, exploratory tours, introduction of salmon trout, engaged the attention of members, by whom numerous papers were read and discussed. In a new country such as Tasmania then was, a knowledge of species and their distribution was not only a matter of scientific interest but also one of vital economic importance, and the naturalists therefore, provided with a rich unexplored field, contributed a wealth of descriptive notes. Some of the prominent workers were Ronald Gunn, Baron von Mueller, John Gould, Dr. Milligan, R. Bastow, Morton Allport, A. Biggs, R. M. Johnston, T. Stephens, W. V. Legge, and J. B. Walker.

The opening of the 20th century forms a dividing line between classical and modern science. The experiments of Bateson, 1897, and the re-discovery of Mendel's work in 1901 resulted in a growing appreciation of the inter-relation of genetics, cytology, physiology, and ecology, and this, coupled with the reaction on scientific progress effected by the researches of Rontgen, Einstein, Bohr, and Rutherford has raised problems which necessitated new approaches and new mothods of analysis. Thus the 20th century has become the era of research institutions and specialized students. The contributions of the Society during the period 1900-1943 should therefore reflect to some extent the influence of this revolution in natural and biological science. The first notable advance was the formation and activity of sections.

Medical Section. In 1896, seventeen members established a Medical Section, prominent members of which were G. H. Butler, E. L. Crowther, A. H. Clarke, and G. Sprott. Many highly technical papers were read and discussed at the Sectional meetings, whilst medical subjects of a more general nature were brought before the Society and public interest aroused in the health of the community. Activities continued until 1912, the Section receiving an annual grant of £12 for the purchase of medical books.

The Southern Branch of the B.M.A. affiliated with the Section in 1912, and, later, having attained an independent status, paid an annual subscription to the Society for the use of the room and the control of the Sectional Library. To the latter was added in 1916, 200 medical books, the gift of Dr. Wolfhagen.

Historical and Geographical Section. Mainly owing to the zeal of J. B. Walker, Bishop Montgomery, and J. W. Beattie, an historical and geographical section was formed in 1899 and resulted in valuable donations to the Library and collections of the Society, e.g., the sketches of (1) Captain Owen Stanley and (2) Simpkinson de Wesselow, as well as contributions of important data relative to early Tasmanian settlement and exploration. After the death of J. B. Walker and the departure of Bishop Montgomery, little was done until 1916, when a section named the Australian History and Economic Section was formed. H. Heaton submitted a

report on the nature and extent of Tasmanian MSS. in the Mitchell Library and J. Moore-Robinson investigated old records in Government Offices with the result that the Society decided to urge the Government to compile a catalogue of old MSS. in the keeping of the various State Departments. Revitalized by Clive Lord, the section, under its original title entered on its period of greatest activity (1921-1933), when much valuable research was done, data collected, and attention directed to the value of historical records of the State. With W. F. D. Butler as Chairman, and J. Reynolds, Secretary, the chief contributors were Clive Lord, W. L. Crowther, J. Moore-Robinson, R. W. Giblin, G. H. Halligan, and J. W. Beattie. The Tasman and other memorials were erected, and attention was directed to the need for preservation of old monuments and burial grounds, e.g., St. David's. The Franklin and other MSS. and much of the valuable Beattie collection of historical relics and papers were obtained. Though some of this work is now undertaken by the Tasmanian Historical Society, the latter owes its origin to active members of the historical section of the Royal Society. Among present contributors to the Society on Tasmanian History, the researches of W. H. Hudspeth, A. L. Meston, W. L. Crowther, H. O'May, and C. Craig are well known to all members. The value of historical records and relics and the necessity to preserve buildings and other old landmarks has frequently been stressed not only by members but also by the Council, which has taken steps to arouse the public conscience in this respect.

Similarly, the Society has made a feature of celebrating anniversaries of important events, e.g. (1) Bowen's Landing at Risdon, 1803; (2) Constitutional Separation, 1825; (3) Sir John Franklin's Arrival in V.D.L., 1837; (4) Tasman's Discovery of Tasmania, 1642. For the Tercentenary of the latter in December, 1942, special meetings were held and relevant papers read.

Psychology and Education Section. The new outlook on Education and the recognition of psychology as a branch of mental science resulted in the formation in 1911 of a new section, viz., Psychology and Education. With S. Clemes, Chairman, and J. A. Johnson, Secretary, 6-8 meetings were held annually. Leading economists and educationists were among the members, e.g., Gordon Wood, D. B. Copland, L. F. Giblin, G. V. Brooks, C. E. Fletcher, E. Morris Miller, W. Clemes, E. E. Unwin, E. L. Piesse, H. T. Parker, L. Dechaineaux, etc., and many fine papers were read and discussed. The meetings continued without intermission until the close of 1936, when the section became an independent body, viz., The Tasmanian Institute for Educational Research.

Biology Section. Though a biology section is mentioned in the report for 1911, no record of its meetings or work is available.

6. Papers and Proceedings of the Society and Other Publications

The scientific work of the Society necessarily entails a review of the papers contributed and of other publications. The Society at first made use of the Tasmanian Journal and not until this ceased publication in 1849, were papers published directly by the Royal Society. An author catalogue of papers presented was compiled by Morton in 1855, and the papers and workers during the period 1843-1900 were reviewed by Morton (loc. cit.) and Maiden (loc. cit.). Since this was the main period of land exploration, settlement, and development, as well as of exploration of the flora and fauna of the colony, it naturally followed that these subjects engrossed the attention of the Society, and of 606 papers listed by Morton on 1901, Zoology numbered 181, Geology 132, and Botany 85, i.e., 66 per cent dealt with Natural Science.

(a) Zoology

In many instances, the zoological papers of the earlier period referred mainly to general macroscopic features and classification, thus leaving a wide field of detailed investigation for the workers of the present century. Governor Weld in the inaugural address 1876 stressed the need for observations on the comparative osteology of marsupials on which, apart from Owen's work, little had been written, and listed fishes, mollusca, crustacea, polyzoa and other phyla which at that date remained comparatively untouched by Tasmanian naturalists.

(i) In Vertebrate Zoology the chief sections dealt with since 1900 have been the following:—

'Tasmanian Vertebrates' and 'Tasmanian Mammals, Living and Extinct' have been the theme of numerous papers by (1) Clive Lord and (2) H. H. Scott.

'Tasmanian Fishes', especially the family Galaxiidae, has been the subject of research more recently of E. O. G. Scott.

'The Anatomy of Marsupials', studied by Owen, 1840-1850, was undertaken by T. T. Flynn (1911-1916) and, since 1935, by Joseph Pearson, whose work has also embraced *(a)* The Blood System, *(b)* Reproduction, and *(c)* Distribution and Colour Variation in Marsupials.

Whales and Dolphins of Tasmania, as well as papers on Heredity are other subjects dealt with by Pearson.

(ii) *Invertebrate Zoology.* In Tasmanian invertebrates a comparatively untouched field awaits investigation. The main contributions since 1900 have been:—

Conchology, which has been well covered by earlier workers, and in this century by W. L. May, who compiled a revised catalogue of marine and fluviatile shells, adding and describing new species (1908-1925).

Arthropoda. (a) Tasmanian Parastacidae have been described and classified by Ellen Clark (1935), Grapsid and Ocypodid crabs by Tweedie (1941), the previous worker on Freshwater Crustaceans having been Geof. W. Smith (1907). The embryology of Anaspides has been traced by V. V. Hickman, Respiratory Organs of Terrestrial Isopods by Unwin, and Tasmanian Caprellidae by Briggs. The Phreatoicoidea have been surveyed by G. E. Nicholls. Part I of his valuable monograph has been published in the Papers and Proceedings, 1942, and Part II appears in the present issue.

(b) In Arachnida, Dr. V. V. Hickman has won international repute as an arachnologist by the comprehensive and exhaustive studies in connection with Tasmanian Spiders, whilst earlier, T. T. Flynn revised Haswell's Australian Pycnogonida and described new forms (1918-1919).

(c) Insecta. The main orders studied have been Diptera (1) by G. H. Hardy and *(a)* A. White (1913-1920); whilst Lea has been the main worker on Coleoptera. A revised list and a description of new species of Tasmanian Lepidoptera have been issued by Jefferis Turner, and Tillyard's valuable researches on (1) Trout Food Insects of Tasmania and on *(a)* The Evolution of Insects have received wide recognition. V. V. Hickman added to our knowledge of Copeognatha (Psocoptera) by describing eight species, 'two of which were archaic forms of more than ordinary interest'. Tas. Sminthuridae (Globular Springtails) were described by Womersley (1931) and recently Plomley has contributed to the systematics of Mallophaga. The specialized work of J. W. Evans (1937-1941) on the taxonomy, morphology, and phylogeny of the Homoptera is of great value to students of entomology.

Mention should also be made of miscellaneous items of zoological interest, e.g., the first freshwater sponge recorded for Tasmania was collected in the Wynyard district by Professor T. T. Flynn, 1922, and proved identical with *Ephydatia multiformis* discovered by the German S.W. Aust. Expedition in Herdman's Lake, N.W. from Subiaco, W. Australia. From the same stream at Wynyard, Flynn also obtained a freshwater Hydrozoan, Cordylophora, which again constituted a new record for Tasmania, and in 1926, two hydromedusoids were recorded by him for the State, whilst in 1932, Hickman and E. O. Scott noted the occurrence of the freshwater polyzoan, *Plumatella repens* (van Beneden).

(b) Botany

Though the work of Tasmanian botanists of the previous century has been covered by Maiden (loc. cit.), but brief reference has been made to the collections acquired by the Society during that period, collections which not only possess a scientific value including as they do many type and co-type specimens, but which also are of rare historical interest. Among such may be listed:—

(a) Specimens of Tasmanian flowering plants presented by J. Milligan in 1852 and in 1869 and rearranged and classified by W. Spicer in 1875.

(b) Collection of Australian plants, presented by F. von Mueller in 1857.

(c) Tasmanian Flowering Plants presented by Gunn and Hooker in 1861, included with which are a small number collected by Ross and Crozier in 1840.

(d) Gunn's Herbarium, the result of 40 years collecting presented to the Society in 1876. This was sent to Sydney in 1904 when the offer of J. H. Maiden to arrange and clean it was accepted.

Between 1900 and 1932, two-thirds of the botanical papers contributed are by Leonard Rodway who during that period published (1) 'The Flora of Tasmania', (2) Tasmanian Ferns, (3) Tasmanian Bryophyta—Vol. I Mosses, Vol. II Hepatics, which included many papers read before the Society. The Mosses and Hepatics included, revised, and expanded the earlier work of Bastow and of Weymouth. Later, various new species of plants were recorded and papers on 'Tasmanian Fungi' by *(a)* Rodway and *(b)* Rodway and Cleland followed. This descriptive index of Tasmanian plants has been of immense advantage to students and provides an enduring monument to the most famous of Tasmanian botanists. In 1928, Rodway, ably assisted by Mrs. Rodway, became Keeper of the Tasmanian Museum Herbarium which had been newly established as the result of the visit of Sir Arthur Hill, Director of Kew Gardens.

From 1928-1932, the Herbarium was at the Botanical Gardens; 1932-1941, at the Tasmanian Museum where the available space became strained by the growing collections. In 1942, therefore, it was removed to its present home, at the Botanical Gardens when Miss W. M. Curtis was appointed Keeper.

In 1931 and also in 1935-36, the Royal Society assisted with the purchase of the Rodway Herbarium (Flora, Mosses, and Hepatics), thus enabling this valuable collection to be retained in the State. The generous gift to the Society by Mrs. Rodway, of the Rodway Botanical Library is proving most useful to students.

Rodway's papers dealt chiefly with systematics, and Maiden's descriptive revision of the Eucalypts has been followed in recent years by R. G. Brett who has undertaken a survey of Tasmanian Eucalypts and their affinities, whilst papers on 'Eucalypts of Tasmania and their Essential Oils' by Baker and Smith, appeared in 1912.

In 1937, the first cyto-genetic paper was contributed by A. L. McAulay and F. D. Cruickshank on the 'Male Meiotic Cycle in the genus Eucalypts' and McAulay has also studied the effect of mono-chromatic ultra-violet irradiation on the 'Production of Saltants of Chaetomium globosum'.

Ecology has received but scant attention, the first paper being read in 1928 when Dr. C. S. Sutton reviewed the vegetation of Cradle Mountain and in 1939, Martin surveyed the Mt. Wellington area.

These papers thus serve to emphasize how limited is our knowledge of Tasmanian flora in regard to the ecology, physiology, embryology, and genetics. One anatomical paper has been read, viz., 'The Stem Anatomy of the genus Richea' (Curtis. 1940).

(c) Geology

The early workers, Milligan, Stephens, Johnston, Petterd, have been mentioned by Morton (loc. cit.) and the period 1902-1921 has been covered by Loftus Hills in a paper on 'The Progress of Geological Research in Tasmania' (Pap. & Proc. Roy. Soc. Tas., 1921). R. M. Johnston's contributions continued till 1918 and to him we owe the greater part of our knowledge of the stratigraphy of Tasmania, and, in particular, of the Permo-Carboniferous system. Petterd will be remembered for his work in mineralogy and his 'Catalogue of the Minerals of Tasmania' which, read before the Society, 1909, and published by the Mines Department, 1910, is still a standard work on the subject. His fine collection of minerals which was bequeathed to the Society in 1910 is on exhibition in the Tasmanian Museum. W. H. Twelvetrees, with whom much of Petterd's work was associated, was responsible for the initiation of systematic geological surveys of definite areas and this, combined with fine mineralogical and petrographical studies, greatly enriched the geological literature of Tasmania. His geological collection is now in the possession of the Launceston Museum. Keith Ward's chief contribution was a survey of the Pre-Cambrian rocks and West Coast areas. Later workers, who have thrown much light on the topography, tectonics and physiography of the island are Col. Legge, W. H. Clemes, A. N. Lewis, P. B. Nye, and A. B. Edwards. A. N. Lewis has given particular attention to the glacial topography of southern areas, e.g., Central Plateau, National Park, Mt. Anne, etc., as well as to a survey of the isotatic background of Tasmanian physiography. Valued contributions on the Permo-Carboniferous and Pleistocene glacial geology were received from Sir Edgeworth David, whilst Griffiths Taylor and Loftus Hills have added appreciably to our knowledge. Of considerable economic importance were the researches of McIntosh Reid on the Oil Shales of Tasmania (1926).

(d) Paleontology

The chief worker in this field was R. M. Johnston, 1883-1918. From 1920 to 1936, H. H. Scott conducted investigations on the flora from the coal fields, other Trias-Jura and Tertiary areas and in 1924-25, Dr. A. B. Walkom studied and reviewed some Tasmanian Mesozoic plants.

Work in Pleistocene and recent deposits received considerable impetus when in 1910 in the Mowbray Swamp, near Smithton, extinct marsupial bones (*Nototherium tasmanicum*, Scott) were discovered for the first time in Tasmania. This was recorded by H. H. Scott and K. M. Harrisson. More important, however, was the subsequent discovery, also in the Mowbray Swamp, in 1920, of a perfect skull and an almost complete skeleton of Nototherium mitchelli. It should be

recorded that the Tasmanian Museum was presented with this splendid specimen through the interest of K. M. Harrisson who made the necessary arrangements with E. C. Lovell, on whose land both skeletons were discovered.

A revision of the genus and its osteology were then undertaken by Lord and Scott and the study and description of these remains have effected a notable advance in the knowledge of the genus.

The same area has since furnished numerous bones which still await investigation. Further important discoveries of extinct marsupial remains were (1) at King Island, and these were assigned by Scott to the genus Palorchestes, (2) from the caves at Mole Creek. The Mole Creek exhibits were presented before the Society by Lord, but no detailed investigation of the area followed.

A considerable amount of work was done by Miss M. Lodder on the Tertiary marine beds at Table Cape. A later investigator of these beds was Sir Edgeworth David and considerable interest was aroused by the discovery of a marsupial from this formation—*Wynyardia bassiana*, Spencer (P.Z.S., 1900), and the interest was maintained when Cetacean remains were obtained from these fossil cliffs. Twenty of the vertebrae are now in the Tasmanian Museum.

Recently A. N. Lewis has been responsible for important discoveries of Lower Ordovician fossils at Junee and Caroline Creek and a new trilobite area at Junee, 1938. In 1940, P. B. Nye reviewed the references to and listed the fossils of the Lower Tertiary marine rocks of the North West of Tasmania, i.e., the area west of Montagu and Balfour.

(e) Natural Science

In this section the most important work was that of Professor Alex McAulay whose 'Researches in Relativity' were deemed of such value that the Society instituted a special fund in order to publish the papers, 1925. 'Optical Gratings' and 'Radiation' were investigated by A. L. McAulay and a recent contributor, R. Cane, has conducted research on the properties and the nitrogen bases of Tasmanite Shale Oil.

(f) Anthropology

Comparatively little attention was paid to this subject during the period 1843-1900, the most notable contributions being from Milligan, J. B. Walker, and A. H. Clarke. Since 1910, however, the subject has aroused considerable interest and prominent workers have been R. W. Legge, Clive Lord, Noetling, A. L. Meston, W. L. Crowther, F. Wood-Jones, and F. Heyward. A. L. Meston's notable discoveries of aboriginal rock carvings at Devonport, 1931, and at Mount Cameron West, 1934, attracted considerable attention, not only in the State, but also on the mainland. N. B. Tindale, Ethnologist to the South Australian Museum, was invited by the Society in 1936, to visit Tasmania in order to report on the best procedure calculated to prevent deterioration of the carvings. Finally, Tindale in his report, recommended the removal to the Tasmanian Museum, for safe keeping, of seven large blocks and treatment *in situ* for the remainder. The Society thereupon approached the Government for financial assistance in order to implement Tindale's recommendations, but unfortunately funds were not available.

Osteological remains of Tasmanian aboriginals were discovered at Eaglehawk Neck, 1918, and also at Tasman Island and Cape Portland. Detailed descriptions of these have been given by Clive Lord and W. L. Crowther and recently all Tasmanian skulls have been reviewed by Wunderly.

(g) History

As mentioned under sectional activities, valuable work has been done in connection with Tasmanian history. J. B. Walker's papers were published under the auspices of the Society in 1901, as a memorial volume, 'Early Tasmania'. Clive Lord awakened an interest in Early Explorers of Tasmania, and other members have added to our knowledge of Bowen, Collins, Early Hobart, Whaling Days, Pioneer Shipping, and the (1) Arthur, (2) Franklin, (3) Denison periods; whilst R. W. Giblin's 'History of Tasmania' is a notable contribution to historical literature.

Increasing facilities for research, interchange between libraries, and the growing appreciation of the value of old documents have resulted in new light being thrown on many historical events. An example of this is the new angle given by Gilsemans' map (a copy of which the Society acquired in 1942) on the site of the first landing place of the Dutch in Tasmania in 1642.

7. GENERAL

Not only has the Society promoted scientific research but also any subject or project which was calculated to promote, either directly or indirectly, the welfare and progress of the community and of the State. From the beginning the Society has taken an active interest in inland and marine fisheries, as is evident from the numerous papers and the prominent part taken by Morton Allport, Sir James Agnew, and Alex Morton in the introduction of salmon and other trout into our inland waters. Finally, a Fisheries Board was established, and on this the Society was represented for many years.

The preservation of natural scenic reserves and the improvement of recreation grounds were subjects in which Governor Weld, warmly supported by the Society, displayed an active interest. The co-operation of the Council of the Royal Society and the active efforts of Russell Young, who introduced the bill in the House, resulted in securing for the people in 1876 the Mt. Wellington Reserve, which finally was vested in the Hobart City Council in 1906. The area thus obtained in 1876 comprised the higher levels and the Fern Tree locality, the City Council acquiring by purchase in later years the northerly and easterly slopes of the mountain. Again, the necessity for retaining Southport Caves as a scenic reserve was mooted by the Society in 1893, whilst in 1918, the Society played a prominent part in obtaining the National Reserve at Russell Falls. The management of the latter area was vested in the National Park Board on which the Society is still represented. Similarly the Northern Branch of the Society sponsored the proposal to reserve the Cradle Mountain-Lake St. Clair region. The reserve was proclaimed in 1922, and members of the Society have been prominent on the Board ever since.

In 1874, the neglected state of the Queen's Domain was discussed by members and proposals in reference to improvement were submitted to the Government by the Council of the Society, with the result that, on receipt of a small grant from the Government, the Society undertook the responsibility of maintenance and beautification. Drives were laid out, avenues of firs, araucarias, etc.. planted, and, as far as funds permitted, attractive recreation grounds developed. Reports from the Domain Improvements Committee appear in the records of the Society for some years, regularly until 1889, when the Queen's Domain Committee Act was passed, and occasionally till 1917, when the Queen's Domain Act vested the reserve in the Mayor and Aldermen of the City of Hobart.

Similarly the preservation of the flora and fauna of the State was constantly stressed by the Council throughout the years until 1928, when the Fauna Board, on which the Society is represented, was established.

The desirability and urgent need of a Biology Department in the University of Tasmania was first discussed by the Royal Society in 1892, following a paper by J. R. McClymont, and, again in 1902, the proposal to establish at the University a practical school of Astronomy awakened considerable interest when the Council devoted much thought to the implementation of the proposal and the possibility of thus securing for Tasmania the benefit of the Leake bequest of £10,000.

It is also of interest at the present time to note that as early as 1919, the Royal Society suggested to the Government that steps should be taken immediately in order to prevent the blackbird becoming a serious pest to fruitgrowers.

The preparation of a union catalogue of the periodicals in the libraries in Tasmania was undertaken by the Council in 1914, and later the Chief Secretary arranged for the necessary funds to cover the cost of printing.

Publications of the Royal Society

In a previous section reference has been made to scientific contributions by members to the Tasmanian Journal, whilst the Royal Society during that period published only annual reports, the 1844 report being published in 1845. Vol. I, Part I, of the Papers and Proceedings of the Royal Society of Van Diemen's Land was published in May, 1849, and a second publication was the Annual Report, but in 1850, original papers and reports of meetings were combined. A complete set of the Society's publications from 1845-1909 were placed in the Library in the latter year, ' probably the only complete set of the publications of the Royal Society of Tasmania '. The volumes were bound in their original covers and two complete sets of annual reports 1845-1892 were also bound. A complete list of publications (Papers and Proceedings, Reports, Pamphlets, and Books) is listed in Papers and Proceedings of the Royal Society of Tasmania, 1913, and to this a supplement was added in 1920. Publication of (1) Reports, or (2) Papers and Reports have been made without intermission, 1845-1943.

The Council in 1913 were anxious to improve the format but funds available only permitted a better quality of paper. The financial position was again a source of concern in 1922, when accordingly the size was reduced. The format of the 1934 issue was improved, and again enlarged in 1939.

The annual publication of the Papers and Proceedings has constituted a serious strain on the financial resources of the Society, and, for many years, the Government has generously assisted, a concession greatly appreciated by the Council.

OFFICERS OF THE ROYAL SOCIETY, 1843 AND 1943

1843	1943
President	*President*
Sir J. E. Eardley-Wilmot, Lieutenant-Governor of V.D.L.	Sir Ernest Clark, G.C.M.G., K.C.B., C.B.E., Governor of Tasmania
Vice-Presidents	*Vice-Presidents*
Sir J. L. Pedder	A. L. Meston
J. E. Bicheno	W. L. Crowther
Rev. John Lillie	
Captain C. Swanston	
Members of the Council	*Members of the Council*
J. Hone	H. Allport
Joseph Allport	V. V. Hickman
W. T. N. Champ	N. P. Booth
Major Cotton	H. D. Gordon
G. T. Boyes	W. H. Clemes
P. Fraser	L. Cerutty
J. Burnett, Senr.	
E. P. Butler	
Treasurer	*Treasurer*
Captain Swanston	S. Angel
Secretary	*Secretary*
W. T. N. Champ	Joseph Pearson

Presidents

The Governor of the State is also the President of the Society and during the century the successive presidents have done much to inspire, maintain, and expand the interests and activities of the Society. To the stimulating influence of Sir George Arthur and of Sir John Franklin, to Sir J. Eardley-Wilmot, the founder of the Society, and to Sir William Denison[1] who re-organized and united the separate institutions[2] the Society is greatly indebted, whilst the scientific interests of some of the later Presidents, e.g., Sir T. H. Lefroy, Sir F. A. Weld, Sir Robert Hamilton, and others contributed largely to its welfare and progress. It is, perhaps, no exaggeration to say that no President has shown a keener interest in the welfare of the Society than our present Governor, Sir Ernest Clark.

---

(1) Later in 1856, he performed a similar service for the Royal Society of New South Wales. Piesse, 1913, p. 118.

(2) Tasmanian Society and the Royal Society. The active members of the former joined the Royal Society 1848-49, being actuated to some degree by the cessation of funds from the Franklin estate.

(a) Captain H. Butler Stoney 'A Year in Tasmania, 1854'.

(b) Launceston Examiner, 18th August, 1849.

Secretaries of the Royal Society—

Wm. Thos. Napier Champ, Secretary, 1843-1844
John Abbott, Hon. Secretary, 1844
George Fordyce Story, Secretary, 1844-1845
John Lillie, Hon. Secretary, 1845-1848
Joseph Milligan, Secretary, 1848-1860
William Archer, Secretary, 1860-1861
Jas. Wilson Agnew, Hon. Secretary, 1861-1881; 1884-1891
James Barnard, Hon. Secretary, 1881-1884
Alex Morton, Assistant Secretary, 1886; Secretary, 1887-1907
Robert Hall, Secretary to the Council, 1908-1913
Fritz Noetling, Hon. Secretary, 1910-1911
E. L. Piesse, Acting Hon. Secretary, 1913; Hon. Secretary, 1914
J. L. Glasson, Hon. Secretary, 1915-1917
Clive E. Lord, Assistant Secretary, 1917; Secretary, 1918-1933
E. T. Emmett, Acting Secretary, 1931
Jean Beattie, Acting Secretary, 1933-1934
Joseph Pearson, Secretary, 1934-
J. W. Evans, Acting Secretary, 1938 (part)

The original rules provided that the Secretary 'shall possess a scientific knowledge of the leading branches of Natural History' and to this policy the Society has adhered when making an appointment.

Joseph Milligan, 1848-1860, continued his interest in the Society, even when he returned to England, as is instanced by his letters and gifts. He also bequeathed to the Society the sum of £350 and two blocks of land, viz., *(a)* three allotments of 1 acre each at Bicheno and *(b)* one town allotment of 3 acres at George Town. The land is still in the possession of the Society.

Alexander Morton (1885-1907) for twenty-two years guided the interests of the Society and is remembered for his wide interests and faithful devotion to the Society and to the Museum, of which he was Curator. Not only did he contribute papers on a variety of subjects, but he also greatly enriched the Society by means of collections which were obtained through his zeal. A mural tablet placed in the Museum records appreciation of his services as Secretary to the Royal Society and as Curator of the Museum. It is worth noting that he also was in charge of the Museum and Art Gallery in Launceston when it was first founded in 1891 and it was 'to be developed on precisely similar lines to those adopted' in the Tasmanian Museum.

Clive E. Lord, Secretary and Librarian, 1918-1933, will always be an honoured name in the annals of the Society. To his energy and enthusiasm must be assigned in no small measure the credit of expanding and maintaining the activities of the Society, whilst his versatility may be judged by the number and range of the papers which he contributed. He received the Royal Society of Tasmania Medal, 1930.

Members

The number of original members nominated by Sir J. Eardley-Wilmot, 14th October, 1843, was 50, including the President. The following list indicates the fluctuations in numbers during the century:—

1843	50	1904	67
1851	275	1913	157
1854	342	1930	266
1863	100	1939	255
1885	176	1942	228

On the Society's roll of Honorary Members occur the names of such distinguished scientists as Sir Edgeworth David, Sir Douglas Mawson, Sir Ernest Shackleton, Sir. W. Baldwin Spencer, Professor E. Wood-Jones, Dr. R. J. Tillyard, and in earlier years Dr. Milligan, Sir Joseph Hooker, John Gould, Count Strzelecki, Professor Owen.

Corresponding members have included—

Sir W. A. Bragg, F.R.S., Professor of Physics (London).

Sir W. B. Benham, M.A., D.Sc., F.R.S.

R. W. Chapman, Professor of Mathematics, University of Adelaide.

A. Dendy, F.R.S., Professor of Zoology, King's College, London.

W. Haswell, F.R.S., Professor of Biology, University of Sydney.

A. Wall, Professor of English Literature, Christchurch, New Zealand.

Though the rules permitted the election of ladies, no names are recorded before 1862. In that year, Mrs. Joseph Allport and Mrs. Morton Allport were elected.

On the Society's present roll is the name of Dr. A. H. Clarke, who has an unbroken record since his election in 1896. For many years he was Chairman of the Council and a member of the Tasmanian Museum Board of Trustees. An even longer record has been achieved by H. D. Foster, a member since 1890.

Subscriptions and Funds

Originally there was an annual subscription of £1, with an entrance fee of £2, and it was to this entrance fee that objections were raised by some members of the Tasmanian Society. The entrance fee was abolished in 1845, but in 1853, in order to make the necessary grant to the Northern Branch, the yearly subscription was increased from £1 to £1 10s. and not until 1912 was it reduced to £1 1s. The Government grant ceased in 1885 and, though assistance has been given by successive Governments towards publication of Papers and Proceedings, the Society since the 1885 Act has been dependent entirely on subscriptions for the maintenance and expansion of the Library and other vital expenditure. The sum £350 (£100 of which was held in trust for the Museum) was received as a legacy from Dr. Milligan. This, however, was not invested, but was placed in the general fund. The Society may well be proud that so much has been accomplished despite the restricted financial resources. Various funds raised by special subscriptions are held in trust and administered by the Society, whilst gifts and bequests of books, pictures, and historical documents too numerous to list have been received.

Memorial Funds and Medals

Morton Allport Memorial Fund (1879)

The sum of £200 was raised by special subscription as a memorial to Morton Allport, a generous donor of collections to the Museum and a contributor of numerous papers, who also took an active interest in the introduction of salmon and other trout. The income accruing from the Memorial Fund is applied to the purchase of scientific books.

R. M. Johnston Memorial Fund (1920)

The sum of £230 was subscribed as a memorial to R. M. Johnston, Government Statistician, a member of the Society from 1883 till his death in 1918, and a Member of the Council and Vice-President for many years. During that time he contributed 103 papers, the subjects embracing statistics, geology, botany, zoology, and palaeontology. He will be remembered not only by students of social and economic science, but also by those interested in Tasmanian geology.

The Memorial Fund provides for (1) Lecture, (2) Medal to be presented to the lecturer, and (3) Purchase of books.

Medals presented—

1923. Sir. T. W. Edgeworth David, K.B.E., C.M.G., F.R.S., F.G.S.

1925. Professor F. Wood-Jones, M.B., B.S., M.R.C.S., L.R.C.P., D.Sc.

1929. R. J. Tillyard, M.A., Sc.D. (Cantab.), D.Sc., F.R.S., F.N.Z.Inst., F.L.S.

1934. Professor W. J. Dakin, D.Sc., Professor of Zoology, University of Sydney.

Clive Lord Memorial Fund (1934)

The fund of £200 was raised by special subscription as a memorial to Clive E. Lord, Secretary and Librarian of the Society and Director of the Tasmanian Museum and Art Gallery, 1918-1933.

The fund provides for (1) A Memorial Lecture and a Medal and (2) A Prize. The lecture shall deal with some aspect of Tasmanian History or Tasmanian Natural Science.

Medals presented—

1936. Professor L. F. Giblin, D.S.O., M.C., M.A., Ritchie Professor of Economics (Melb.).

1939. Professor J. B. Cleland, M.D.

Clive Lord Memorial Prize

Awards—

1939. R. J. Linford.

A bronze memorial mural tablet was also erected in the Museum.

Rodway Memorial Fund (1936)

The fund was raised by subscription as a memorial to Leonard Rodway, and was expended as follows:—

1. Florence Rodway was commissioned to paint a portrait of her father. This painting hangs in the Art Gallery.
2. The balance was applied to the purchase of botanical books for the Library.

J. W. Beattie Memorial Fund (1937)

The memorial was established in recognition of the outstanding work of J. W. Beattie in connection with historical relics and documents. The fund has been applied to the purchase of modern books on Australian history, geography, and anthropology.

Royal Society of Tasmania Medal

An addition to the Rules in 1927 provided for the establishment of the Royal Society of Tasmania Medal to be awarded 'for pre-eminence in research in any of the branches of knowledge coming within the purview for the time being of the Society.

Awards—

1928. Leonard Rodway, C.M.G.

1930. Clive E. Lord, F.L.S.

1934. H. H. Scott, Curator, Queen Victoria Museum and Art Gallery.

1935. A. N. Lewis, M.C., LL.D.

1940. W. L. Crowther, D.S.O., M.B.
V. V. Hickman, D.Sc., B.A., C.M.Z.S.

Brief as this review must necessarily be, it yet serves to indicate the progress and development of the Society and the contributions to science and to the community made by its members throughout the century which has elapsed since 14th October, 1843 In the years that lie ahead, the Society, therefore, may confidently expect that not only will its traditions be maintained, but that its influence in the community and its contributions to the advancement of knowledge, and particularly to science, will increase in value and importance.

PLATE VII

1. Sir J. E. Eardley-Wilmot, Lt.-Governor of Van Diemen's Land. Founder and First President of the Royal Society of Tasmania.

2. Sir Ernest Clark, G.C.M.G., K.C.B., C.B.E. Governor of Tasmania. President of the Royal Society of Tasmania, 1933-

3. Centenary Medal.

Awards—

1943. Eric Ashby, D.Sc., D.I.C., Professor of Botany, University of Sydney.
George Mackaness, O.B.E., M.A., Litt.D.

ROYAL SOCIETY OF
TASMANIA
FOUNDED
14 OCTOBER 1843

1843
1943
AWARDED TO

PLATE VIII

Council of the Royal Society of Tasmania, 1943.

Sitting (l. to r.) :—J. Pearson (Hon. Secretary), W. L. Crowther (Vice-President), H.E. Sir Ernest Clark (President), A. L. Meston (Vice-President), S. Angel (Treasurer).

Standing (l. to r.) :—H. D. Gordon, N. P. Booth, H. Allport, L. Cerutty, V. V. Hickman, W. H. Clemes.

PLATE IX

1. Royal Society Library, 1900-1930.

2. Royal Society Library, 1943.

Centenary of the Royal Society of Tasmania

By the Honorary Secretary

The Royal Society of Tasmania celebrated its Centenary in October, 1943. In another part of the present volume (p. 199) Miss Somerville discusses the history of the Society, which was founded by Sir J. E. Eardley-Wilmot, Bart., Lieutenant-Governor of Van Diemen's Land, on 14th October, 1843.

At the Canberra Meeting of the Australian and New Zealand Association for the Advancement of Science in January, 1939, it was decided that the Association should meet in Hobart in the Centenary year of the Royal Society of Tasmania in order to take part in the Celebrations, but owing to the outbreak of war, it was decided to hold no further meetings of the Association until after the war. The Council of the Royal Society of Tasmania, however, decided that, in spite of the war, the Centenary should be celebrated in a fitting manner, and it was agreed to invite Professor Eric Ashby, of the University of Sydney, and Dr. George Mackaness, of the Teachers' College, Sydney, to deliver lectures during Centenary week. The Government of Tasmania generously contributed £100 towards the cost of the Centenary Celebrations.

Owing to travelling restrictions ordained by war-time requirements, the Celebrations were not attended by visitors from the Mainland, with the exception of Mr. D. J. Mahony, who represented the Trustees of the Public Library, Museums, and National Gallery of Victoria. The Royal Society of Victoria asked Dr. Thomas, Government Geologist, who was then resident in Hobart, to represent that Society.

The Council and Office-bearers of the Society in the Centenary year were as follows:—

President: His Excellency Sir Ernest Clark, G.C.M.G., K.C.B., C.B.E.

Vice-Presidents: A. L. Meston, W. L. Crowther.

Members of Council: H. Allport, V. V. Hickman, N. P. Booth, H. D. Gordon, W. H. Clemes, L. Cerutty.

Hon. Secretary and Editor: Joseph Pearson.

Hon. Treasurer: S. Angel.

A group photograph of the Centenary Council and office-bearers is given on plate VIII.

The following is a list of the functions given on the occasion of the Centenary:—

Tuesday, 12th October, 1943.—An evening meeting in the Royal Society's Room, Tasmanian Museum, presided over by His Excellency the Governor, His Excellency, who is also President of the Society, opened the proceedings with an address (see p. 224). This was followed by a lecture delivered by Dr. George Mackaness, O.B.E., M.A., Litt.D., on 'Captain William Bligh's Discoveries in Tasmania'.

Wednesday, 13th October, 1943.—A morning reception was given by the Lord Mayor of Hobart at the Town Hall. A garden party was given by the Council at the Botanical Gardens in the afternoon. In the evening the Council and office-bearers were the guests of His Excellency the Governor and Lady Clark at a dinner at Government House. The visiting lecturers (Professor Ashby and Dr. Mackaness); the Premier; the Chief Secretary; the Lord Mayor of Hobart; Mr. J. Smithies, President of the Northern Branch; and Mr. D. J. Mahony, representing the Trustees of the Public Library, Museums, and National Gallery of Victoria, were also present.

Thursday, 14th October, 1943 (Centenary Day).—An evening meeting in the Royal Society's Room, Tasmanian Museum. A large and distinguished gathering was present. In his introductory remarks His Excellency the Governor, as President of the Society, expressed the hope that the Society would have an even greater influence in the future than it had had in the past one hundred years. His Excellency also made a plea that the facilities afforded by the Society should be used more freely by citizens. He felt that the community did not appreciate as fully as it might the work which the Society had done. The Honorary Secretary read congratulatory messages received from Societies and others (see p. 229). His Excellency presented Centenary Medals to Dr. Mackaness and Professor Ashby (see p. 227). Professor Ashby, D.Sc., D.I.C., delivered an illustrated lecture on 'A Century of Ideas on Evolution'. The proceedings terminated with a conversazione held in the Art Gallery.

During the Centenary week a special historical exhibition was displayed in the Museum, consisting mainly of loans from the following:—His Excellency the Governor, The Shiplovers' Society, Tasmanian Club, Mr. C. E. Radcliff, Miss Knight, Miss Andrews, Miss Cutmear, Dr. W. L. Crowther, Miss D. Bisdee, Dr. W. W. Giblin, Mr. W. T. Stops, Mr. E. Webster, Mrs. R. C. Hodgman and Sister Read, Mr. A. J. R. Miller, Southern Tasmanian Philatelic Society, Mr. N. Hurst, Mr. A. Pedder, The Diocesan Office, Mrs. A. Abbott, Mr. F. Abbott, Mrs. C. Baldwin, Mrs. A. Buring, Mrs. W. F. D. Butler, Mr. Westbrook.

Replicas of the Centenary Medal have been sent to The Royal Society, London, The Royal Society of New South Wales, The Royal Society of Victoria, The Royal Society of Queensland, The Royal Society of South Australia, The Royal Society of Western Australia, and The Royal Society of New Zealand.

The following is the text of His Excellency's address given on Tuesday, 12th October, 1943, on the occasion of the opening of the Centenary Celebrations:—

In these days, when we are urged to practise austerity, I am ambitious to display that virtue in my opening remarks, in order that you may have more time to enjoy the interesting mental pabulum certain to be provided by Dr. Mackaness, who has a profound knowledge of Captain Bligh, a man whose character and achievements greatly interest all Australians. I propose, therefore, to make only a brief reference to the hundred years' history of the Royal Society of Tasmania, especially as that history is in the Society's Papers and Proceedings for 1894, 1900-1901, and 1913, and has been brought up to date in an admirable paper by Miss Somerville, which will be published in the Society's Proceedings for this year.

The Royal Society of Tasmania can claim to be the oldest genuine scientific Society in Australia; it has existed since 1843, without a break in its meetings, and it has an uninterrupted series of publications since 1844. According to its

original rules, the leading objects of the Society were 'to develop the physical character of the Island, and illustrate its natural history and productions'. In 1907, its new rules stated that 'the objects of the Society were the prosecution of the study of science in its various branches, and more especially the development of a knowledge of the physical characters and natural history of Tasmania and the neighbouring States'. In 1914, when it was deemed advisable to broaden the definition of the Society's aims, its object was declared to be 'the advancement of knowledge'; a noble object; not lacking in ambition!

Let us consider for a moment the handicaps under which the original pioneers of the Society laboured. In 1843 there were only about fifty thousand people in this State, i.e., two to the square mile, and we must frankly admit that half of that population was, to say the least, the rejected of the land of their birth. Not very fertile ground upon which to raise a flourishing scientific Society!

But there is another side to that question; Tasmania had this advantage, that among the free settlers who came to its shores in the early part of the 19th Century, there seems to have been those who were the 'salt of the earth'; men who possessed the pertinacity and imagination of the true scientist; who had spiritual as well as scientific aspirations, as is evidenced by the places of worship they built (large enough to serve double our present worshippers). To them we are indebted for the inauguration and successful carrying on of the Society in its early years. There must have been among these free settlers great hearts, imbued with faith, hope, and ambition.

At that time men laboured under the disadvantage of a lack of that vast knowledge which the past century has accumulated and presented to us; but, on the other hand, they were not subject to so many distractions as we are; were not tempted from the hard path of scientific endeavour to tread the viciously easy paths of amusement; or seduced to acquire (and forget) knowledge seen on pictures or heard over the radio. In spite of working harder than we do, they had, therefore, more time for true intellectual endeavour.

Let me remind you that, throughout its career, the Royal Society of Tasmania has been materially assisted by the Government of the State in many ways, and continues to enjoy this support. This building in which we sit is an instance; it was two-thirds paid for by the Government, and only one-third of its cost was raised by public subscriptions. For such government assistance, the Council is truly grateful.

But I am not sure that all its connections with the Government have been a cause for gratitude; for instance, the rules of the Society provide that its President is to be the Governor of the State for the time being. The Society was founded late enough to escape the attentions of two 'bad' Governors, who were relieved of their office, but unfortunately it also missed the services of Sir George Arthur, a great administrator, and the real maker of early Tasmania, and also of Sir John Franklin, a fine sailor, a great explorer, and a scientist, who formed in 1838 the Tasmanian Society, which was the real foundation of our own Society. Sir John's interest in science is shown by the assistance he gave to his friend, Captain Ross, in the investigations for the determination of the position of the South Magnetic Pole. Incidentally, it is interesting to know, that he showed that 'hustle' which to-day we associate with our American allies, for he completed the building of the little Observatory (of which traces still remain in Government House grounds) in nine days. Ross records this as follows:—

'Under the daily personal superintendence of Sir John Franklin the building of the Observatory proceeded most rapidly, and the whole was completed, the instruments placed, and all their delicate adjustments fulfilled, a few hours before

the observations of the 27th August were to be commenced. The erection of this Observatory was accomplished in nine days—an instance of what may be done where the hearts and energies of all are united to promote the common object of their endeavours'.

He might have been writing about the war to-day! He continues: 'I should do injustice to my feelings unless I expressed my admiration of the cheerful enthusiasm which the convicts displayed throughout the work. After they had been labouring from six o'clock on Saturday morning until ten at night, seeing that a few more hours of work would complete the roofing, they entreated permission to finish it before they left off; but as this would have broken in upon the Sabbath morning, their request was very properly refused'.

All the succeeding Governors of Tasmania have not been of the calibre of Arthur and Franklin, and perhaps they have not had quite such energetic helpers as those just described. The very first Governor-President of the Society was removed from his office of Governor ignominiously (though perhaps he did not deserve that fate); and the present occupant of the joint office is conscious of the inadequacy of his qualifications for the presidency of a Royal Society, his scientific knowledge being confined to finance, and the so called 'dismal' science of political economy. The Governor of a State is, *prima facie*, not the most likely person to be a scientist, as his position is administrative rather than scientific. It is his province to apply the knowledge of others, though from long experience I can affirm that he needs to possess some of the qualities of the scientist, such as impassivity, patience, perserverance, impartiality, unprejudiced judgment, and resilience after defeat. Scientists and governors alike need to know the lesson Bruce learnt from the spider.

A careful study of the history of the Society reveals very clearly the enormous debt it owes to the devotion and enthusiasm of its members, who during the last hundred years have made it a potent force in the provision of intellectual food for the people of this State; in fact, have enabled it to live up to its professed object, 'The advancement of knowledge'. The number of such members is too many, and their achievements too great for me to attempt to describe them in detail; they have laboured to advance man's knowledge of the sciences and arts of History, Geography, Zoology, Botany, Geology, Paleontology, and Anthropology. They established the Museum and Botanical Gardens, and have accumulated an invaluable library of some 20,000 volumes. We have faith that, though the names of these workers may fade into oblivion, their work will remain and bear fruit, not only here, but in extent beyond our shores, and in time beyond our generation.

In such an introductory address as this, it may not be altogether out of place to refer to some of the characteristics which these men necessarily possessed, in order to be able to give the help they did to this Society, and to this State, from the middle to the end of the 19th Century. They, whose labours we have inherited, had a somewhat different task to the scientist of to-day, for starting at a time when there were many less proved facts than we possess they had a much greater field for exploration, with many less reliable instruments suitable for their task. On the other hand, the scientist of to-day is, perhaps, hampered rather than helped by the immensity of the number of already discovered facts; in other words, the human capacity to assimilate knowledge may be stretched to its uttermost, in the case of the scientist of to-day, even before he arrives at the place from which to start for the unknown, which is his goal. Let us recollect that the true scientist is not a mere adapter, but a man allied in character to the inventor. His imagination must wander through the unmeasured world which surrounds the particular subject of his investigation. While he must be prepared to prove all things, in

order that he may hold fast that which is good, yet he must be forever exploring new paths in order to acquire greater knowledge, seeking constantly to draw fresh supplies from the 'Well of Truth'. I am not speaking only of knowledge of his own subject, but of the vast volume of constantly changing knowledge, almost inexhaustible in regard to the subjects allied and cognate to that which he is studying, that region of unfathomable dimensions, almost unimaginable in its complexity.

The scientists of a hundred years ago had to discover, or were in the midst of discovering, things which to us are obvious everyday truths. On their successful efforts we are able to build, for we are the heirs to a long line of noble predecessors, and upon us is laid the duty of utilizing to the full the knowledge that they acquired with such unfaltering endeavour. We should be encouraged by the certainty that no tiniest feather falling from the Great White Bird of Truth is ever wasted by the true scientist who finds it. (Those who remember the wonderful allegory of truth in Olive Schreiner's 'Story of an African Farm' will understand my allusion.)

It is difficult to judge of the exact effect produced by such an Association as the Tasmanian Royal Society, if it is regarded over a brief period; but on such an occasion as this, when we are looking back for a hundred years, we must be grateful not only for its survival as a Society, but as citizens of the State must also be grateful for what has been accomplished by its members and others who have kept alive the light of culture and progress, far from the centre of many scientific activities; have even had the courage to put forward new ideas and ideals, a process which is generally anathema in an isolated self-contained community. Here I finish, with apologies for the length of my introductory address. It might perhaps have been more interesting to you, it would certainly have been easier for me, if I had spoken at greater length on the details of the history of the Society, but in these things one can only do what one is constrained to do.

The following is the text of the speeches made by His Excellency the Governor in presenting the Centenary Medals to Dr. Mackaness and Professor Ashby:—

To-night it is my pleasure to be able to say a few words in laudation of those two eminent scientists who have graced our Centenary by their presence and informed our minds by their erudition.

I deem myself fortunate in being deputed to hand to Dr. George Mackaness and Professor Eric Ashby the special Medals, which have been struck by this Royal Society to commemorate its Centenary.

These medals do not merely indicate our appreciation of the Papers which our eminent visitors have prepared for the Society, but serve also as a commemoration of our hundred years of scientific effort. The recipients are the present representatives of that long line of eminent scientists who have rendered service to the Royal Society, and to the community—men who, if by the effluxion of time they become anonymous, have, nevertheless, left to this and succeeding generations precious results of their toil.

Dr. Mackaness' Paper is part of that historical lore which he has acquired by intensive research. I know of no subject more important that his own for the average Australian to make part of his mental equipment. A young country needs to acquire a sense of history, in order that it may truly judge of its relative position to the rest of the world, and also in order to give it that perspective view of the past, which is essential if a true perspective is to be obtained of the future. In other words, if we would proceed aright along the road which lies before us,

we in Australia must have a clear view of the roads, the paths, and the tracks which lie behind us, and this view Dr. George Mackaness is able to give, and has indeed given, to the Australian public.

Dr. Mackaness is more than amply qualified for the task which he has generously undertaken by visiting us; not without some pleasure to himself, I hope; this you will realize if I remind you that he is Senior Lecturer of the Teachers' College, Sydney, a Member of the Educational Broadcast Advisory Committee, and an author of three outstanding historical publications. He is a Member of the Board of the Commonwealth Literary Fund, and formerly President of the Fellowship of Australian Writers.

Dr. Mackaness, I have great pleasure in handing to you this Commemoration Medal, with the thanks of the Royal Society of Tasmania, for the help which you have rendered to us, by your presence at our Centenary.

I base an expression of my admiration for Professor Ashby's work on the testimony of another scientist, eminent in the Professor's own subject, and also on the testimony of a leading member of the commercial community, who had had practical experience of the extreme usefulness of Dr. Ashby's scientific work for Australia.

Dr. Ashby is a botanist of unusual versatility. As a Commonwealth Fund Fellow he was engaged in botanical researches in America from 1929 to 1931. He was one of a group which carried out a series of important studies at Imperial College, London, on factors affecting plant growth, and rapidly became a recognized authority on plant ecology. Before he had been a year in this country Dr. Ashby was elected President-designate of the Botany Section of the Australian and New Zealand Association for the Advancement of Science for the Adelaide Meeting which, unfortunately, has not yet been held on account of the war.

He has shown himself keenly alive to the importance of primary production in Australia, and of the agricultural aspects of Botany. He has had wide experience in the fruit world, and spent some time in the famous Hood Valley of America, working on food storage. This experience has proved of great value to Tasmanian fruitgrowers, as in 1937 and 1938 the evidence given by him was responsible for a decision in the law courts in London, that it was the carriage of fruit that caused the breakdown in Tasmanian apples, and that disease of brown heart was caused after the fruit left the orchard, and not during the growth of the apple.

Previous to this, all claims made against the shipping companies for faulty carriage were refused, it being maintained that brown heart in apples was an inherent vice.

Dr. Ashby was elected Chairman of the Australian National Research Council, and with a colleague was chosen to report to the Government on the use that was being made of Australia's scientific resources in war-time. As a result of this report the Scientific Liaison Bureau was established, and Dr. Ashby acted as the Bureau's first Director.

Professor Ashby, to you also, with this commemortive Medal I give the very sincere thanks of the Royal Society of Tasmania, for the help which you have rendered by visiting us and for preparing a Paper, which will be published in our Papers and Proceedings, on the intensely interesting subject of Evolution, which you are treating in a historical sense, appropriate to the fact that we are celebrating our existence during the century to which your paper refers.

The following messages were received on the occasion of the Centenary Celebrations:—

From the Premier of Tasmania

On behalf of the State Government, may I convey to the President, the Council, and members of the Royal Society of Tasmania our congratulations on the important event now being celebrated.

It is fitting that we should pay a tribute at this time to that small group of people who, with the encouragement of Sir Eardley-Wilmot, Lieutenant-Governor of the Colony, founded the Society 100 years ago. Thanks mainly to the Society's endeavours, there afterwards came about the establishment of the Botanical Gardens and the Tasmanian Museum, since maintained on slender financial resources. These annual maintenance grants, incidentally, are being increased as from the beginning of the current fiscal year.

In the Statute which incorporates the Society, it is recorded that the Society was established for the prosecution of the study of science in it various branches, and more especially for the development of a knowledge of the physical character and natural history of Tasmania and the neighbouring States'. I have no doubt that your Council will continue to carry out that trust faithfully, thus keeping step with learned bodies in other parts of the world.

In this work, you have the support of the Government. I now extend my good wishes to all those who promote the activities of the Society, and particularly to those distinguished visitors who have been able to come to Hobart to join in your Centenary Celebrations.

As I cannot be present at to-night's meeting, to which your Council kindly invited me, would you please apologize for my absence.

ROBERT COSGROVE, *Premier.*

From the Chancellor of the University of Tasmania

Since its foundation in 1890 the University has been closely associated with the Royal Society of Tasmania. Indeed the Royal Society was prominent in the original movement for the establishment of a University in this State.

The Centenary of the Royal Society is therefore an historic occasion of more than ordinary interest for the members of the University, and I am desired to express to the President, and Vice-President, and the members of the Royal Society the most cordial congratulations of the University of Tasmania and to wish the Society an undiminished continuance of its high achievements in the realms of service and culture.

From the date of the foundation of the University its professors have published results of their researches in the Proceedings of the Royal Society. . . . I think it not necessary to hope, because it is certain, that the co-operation with the Royal Society of Tasmania, which began from the foundation of the University, will continue to the end.

W. J. T. STOPS, *Chancellor.*

From the Australian and New Zealand Association for the Advancement of Science

On behalf of the Australian and New Zealand Association for the Advancement of Science I take this opportunity of offering hearty and sincere congratulations to the Royal Society of Tasmania on the completion of its first hundred years and on the scientific work it has accomplished during that period. The occasion is worthy of far greater recognition by scientists throughout Australia than is possible under existing conditions, and members of my Association will always regret that it was not possible to meet in Tasmania this year and so to extend greetings and felicitations in person. They all look forward to a successful continuance of the Society's work and to even greater achievements in the future.

With best wishes for a successful celebration.

A. B. WALKOM, *Honorary General Secretary.*

From the Royal Society of New South Wales

On behalf of the President, Council, and members of the Royal Society of New South Wales, I have the honour to congratulate the Royal Society of Tasmania on reaching its Centenary, and of wishing your Society a very happy and successful celebration of this event.

Your Society has performed during its one hundred years a very valuable service for science in Tasmania and Australia, as well as making a most valuable contribution to Australian life in general.

While expressing our felicitations to your Society for its past achievements, we also wish it great success in its work during the next one hundred years.

A. P. ELKIN, *Honorary Secretary.*

From the Royal Society of Victoria

The Royal Society of Victoria acknowledges and reciprocates the greetings from the Royal Society of Tasmania, and offers its congratulations on the attainment of the hundredth anniversary of the foundation of the Royal Society of Tasmania. It also desires to thank your Council for the proposed gift of a commemorative medal.

FRANK L. STILLWELL, *Honorary Secretary.*

From the Royal Society of South Australia

The President and members of the Council of the Royal Society of South Australia wish to convey congratulations and greetings to the Council and members of the Royal Society of Tasmania on the occasion of their Centenary.

W. TERNENT COOKE, *President.*
R. L. CROCKER, *Hon. Secretary.*

From the Royal Society of Queensland

Telegram.—Congratulations on attaining Centenary. Best wishes for future success from Royal Society of Queensland.

From the Royal Society of Western Australia

I am instructed on behalf of the Council and members of the Royal Society of Western Australia to send greetings and congratulations to the Royal Society of Tasmania on the attainment of the one hundredth anniversary of its foundation, and all good wishes for the success of the meetings to be held to celebrate this event.

A. G. NICHOLLS, *Joint Hon. Secretary.*

From the Trustees of the Public Library, Museums, and National Gallery of Victoria

I am desired by the Trustees of the Public Library, Museums, and National Gallery of Victoria, to write to the Royal Society of Tasmania on the occasion of its Centenary celebrations.

We desire to congratulate your Society on its 100th birthday, and on all that it has done during its long period of activity. As the oldest Royal Society outside Great Britain, it holds a special position in the British Empire. We know it has always been an active body, and has published much good research work.

We have asked Mr. D. Mahony, Director of our National Museum, to represent the Trustees at your celebrations, and trust that your Society will accept him as our representative.

KEITH MURDOCH, *President.*

From the Australian Chemical Institute, Tasmanian Branch

The President and members of the Tasmanian Branch of the Australian Chemical Institute wish to extend their heartiest congratulations to the President and members of the Royal Society of Tasmania on the occasion of the attainment of the hundredth year since the foundation of the Royal Society of Tasmania, and, to convey their best wishes for the success of the functions to be held in connection with the Centenary celebrations and for the continued progress of the Society.

J. L. SOMERVILLE, *President.*
GEO. C. ISRAEL, *Hon. Secretary.*

From the Mayor of Launceston

Whilst writing to you it would not be fitting on my part if I did not refer to the service which your Society has rendered during the 100 years of its existence. Its contribution to the cultural and scientific life of our community has proved of great benefit, and I sincerely trust that the Society will continue to function in a successful manner.

On behalf of this Council and citizens of Launceston I desire to convey our hearty congratulations.

DESMOND OLDHAM, *Mayor.*

From Mr. E. L. Piesse

As a member, now of rather long standing, of the Society, a former member of its Council and for some time its Honorary Secretary, I have received with pleasure the programme for the celebration of its Centenary and the invitation of the President and Council to be present.

I recall that when, thirty years ago, for the occasion of the Society's seventieth birthday, I wrote an account of its early history, I had in mind that I might be at its Centenary. But two world wars have intervened; the first took me away from Hobart in 1914, terminating my honorary secretaryship, and the consequences of the second are an obstacle to my returning even for these celebrations.

Our Society has for a century provided interest for its members and increase of knowledge for the public at large. It enters active and vigorous upon its second century. I join with my fellow members in hoping that the Society, now one of the oldest institutions of Tasmania, will long continue the useful life of which it shows full promise.

E. L. Piesse.

The Royal Society of Tasmania

1943

Patron:

His Majesty the King.

President:

His Excellency Sir Ernest Clark, G.C.M.G., K.C.B., C.B.E.

Vice-Presidents:

A. L. Meston, M.A., 1943.
W. L. Crowther, D.S.O., M.B., V.D., 1943-44

Council:

H. Allport, LL.B., 1943, 1944, 1945.
V. V. Hickman, B.A., D.Sc., 1943, 1944, 1945.
N. P. Booth, 1943, 1944.
H. D. Gordon, B.Sc., Ph.D., 1943, 1944.
W. H. Clemes, B.A., 1943.
L. Cerutty, B.A., Dip.Ed., 1943.

Hon. Secretary and Librarian:

Joseph Pearson, D.Sc. (Manchester), D.Sc. (Liverpool), F.R.S.E., F.L.S.

Hon. Treasurer:

S. Angel.

Hon. Auditor:

H. J. Exley, M.A.

Hon. Editor of the Papers and Proceedings:

Joseph Pearson.

Standing Committee:

W. L. Crowther, E. E. Unwin, V. V. Hickman, J. Pearson.

Annual Report, 1943

The Annual Meeting was held in the Society's Room, Tasmanian Museum and Art Gallery, Hobart, on the 23rd March, 1943.

The following Office-bearers were elected:—

Vice-President: Under the Society's Rules, Mr. H. Allport retired from the office of Vice-President, and Dr. W. L. Crowther was appointed in his place (retiring 1945).

Treasurer: Mr. S. Angel.

Council: Under the Rules, Dr. W. L. Crowther and Mr. E. E. Unwin retired from the Council, and the following members were elected to the Council in their place:—

Mr. H. Allport (retiring 1946).
Dr. V. V. Hickman (retiring 1946).

The Council made the following appointments at its first meeting:—

*Secretary and Librarian: Dr. Joseph Pearson.
Assistant Librarian: Mrs. Clive Lord.
Standing Committee: Dr. W. L. Crowther, Mr. E. E. Unwin, Dr. V. V. Hickman, and the Secretary.

The Council elected the following two Trustees to serve on the Board of Trustees of the Tasmanian Museum and Art Gallery and the Botanical Gardens:— Mr. W. H. Clemes and Mr. E. E. Unwin.

Ten meetings were held during the year (see proceedings for abstracts of papers). In addition scientific papers were submitted for publication and have been printed in the present volume.

Library

During the year 163 volumes were added to the Library in addition to a number of reports and pamphlets from British and foreign institutions and learned societies. The number of institutions on the Exchange List for the year was 276. Extending the practice which at first was confined only to European countries, it has now been decided to withhold all British and foreign exchanges until the conclusion of the war, with the exception of a few special cases. The Library now consists of 20,428 volumes.

The sum of £53 3s. 1d. was spent on books during the year, and the account allocated as follows:—

	£	s.	d.
General Fund	35	11	9
R. M. Johnston Fund	8	6	10
Morton Allport Memorial Fund	9	4	6

In addition, the Tasmanian Museum spent £2 6s. 9d. on books, which have been placed in the Society's Library for safekeeping, and are available to members.

* The title of this office, as regards its present holder, was altered to Hon. Secretary and Librarian, by a resolution of the Council on 1st October, 1943.

Membership

The Society consists of the following members:—

	1942.	1943.
Honorary Members	2	2
Corresponding Members	3	3
Life Members	6	6
Ordinary Members	213	220
Associate Members	4	3
	228	234

During the year 13 names were removed from the list of Ordinary Members owing to deaths, resignations, etc., and 19 new members were elected.

One Ordinary Member became a Life Member, and the resignation of one Associate Member was received.

Deaths

The Council regrets having to record the deaths of the following members during the year:—Mr. C. W. Grant (Life Member), Mr. G. H. Halligan, The Rt. Rev. R. S. Hay (Bishop of Tasmania), Mr. A. B. Raymond-Barker, Mr. R. O. M. Miller, and Dr. A. N. Lewis.

Dr. A. N. Lewis had been a member of the Council for many years and, on occasion, Vice-President. A full obituary notice is contained in the present volume.

Centenary Celebrations

During the year the Society celebrated its Centenary, having been founded on the 14th October, 1843, by Sir J. E. Eardley-Wilmot, Bart., Lieut.-Governor of Van Diemen's Land. The Council decided to hold special meetings to celebrate this event. An account of these meetings is dealt with in another part of this volume (p. 223).

A special medal was struck to celebrate the Centenary. Each of the two lecturers received a medal, and replicas were sent to the Royal Society of London, the Royal Societies of New South Wales, Victoria, Queensland, South Australia, Western Australia, and the Royal Society of New Zealand. It was agreed by the Council that silver-plated replicas should be struck in case members of the Society wish to acquire them. These replicas may be obtained by application to the Secretary.

His Excellency the Governor

On 4th August the President of the Society, His Excellency Sir Ernest Clark, G.C.M.G., K.C.B., C.B.E., completed ten years of office, and on that occasion he was honoured by His Majesty the King by the bestowal of the G.C.M.G. The Society sent him the following telegram:—

> 'The Council and members of the Royal Society of Tasmania send Your Excellency and Lady Clark cordial greetings on the completion of ten years of office as His Majesty's representative in Tasmania. Further they wish to express their deep appreciation of the kindly interest which Your Excellency and Lady Clark have always shown in the affairs of the Society. They earnestly desire that you may both be spared for many years of happiness'.

His Excellency sent the following reply:—

'Dear Mr. Pearson,

My Lady Wife and my self are greatly moved by the kind expressions of appreciation and the good wishes conveyed to us from the Council and members of the Royal Society, by their telegram of the 4th.

It has been a very great pleasure indeed to have been so closely associated for so long with the Royal Society, and it is nice to know that this feeling is reciprocated. Such things are a great help in the none too easy task of properly carrying out my duties under war conditions.

Yours sincerely,

(Sgd.) E. CLARK'.

Future Policy of the Society

At the November meeting a preliminary discussion took place regarding the future policy of the Society, and it was then decided to hold a further meeting early in 1944, in order to discuss, and, if possible, formulate the future policy of the Society.

Printing of Papers and Proceedings

Once again the Government has very generously printed the Papers and Proceedings. The Council wishes to record its appreciation of this assistance.

Abstracts of Proceedings

23RD MARCH, 1943

Annual Meeting

The Annual Meeting was held in the Society's Room, Tasmanian Museum. The President, His Excellency the Governor, presided.

The following were elected Office-bearers and members of the Council for 1943:—Dr. W. L. Crowther was elected Vice-President in the place of Mr. H. Allport, who retired under Rule 12; Mr. H. Allport and Dr. V. V. Hickman were elected in the places of Dr. W. L. Crowther and Mr. E. E. Unwin, who retired under Rule 21; Treasurer, Mr. S. Angel.

Mr. H. J. Exley was appointed Hon. Auditor.

The following were elected members of the Society:—Miss E. M. Harvey, Miss G. E. Morris, Mr. L. H. Livingston, Dr. D. E. Thomas.

The following alteration to Rule 9 was approved by the meeting on the motion of His Excellency the Governor, seconded by Dr. Evans:—

Rule 9.—The words 'and shall be sent to the Secretary not later than the 31st January of the year of election, unless the Council fixes an earlier date in any particular year' to be deleted and in their place the following to be substituted 'and shall be sent to the Secretary not less than fourteen days before the date of the Annual General Meeting'.

At the end of Rule 9, the following to be added:—'In the absence of any nominations, members present at the Annual General Meeting shall have the right to elect Office-bearers and to fill vacancies in the Council for the ensuing year as provided by the Rules of the Society'.

The Secretary made a few comments on an exhibit of mineral labelled 'Beauxite from Port Davey', which belonged to the Petterd Mineral Collection. It was pointed out that in Petterd's Catalogue of the Minerals of Tasmania he stated that this specimen agreed fairly well with the general characteristics of bauxite, although no complete analysis had been made. The Government Geologist, Dr. Thomas, has now reported that this specimen is a bleached and sheared micaceous shale, and in no way resembles bauxite. The bedding and cleavage planes which intersect at a small angle are clearly visible to the naked eye. Dr. Thomas gave the following comparison between the composition of bauxites and shales:—

	Bauxites			Shales (average of 78 shales)
	%		%	%
SiO_2	2	—	20	58
Al_2O_3	45	—	60	15
Fe_2O_3	1	—	25	6
TiO_2	1	—	3	1

It follows that this specimen is too poor in alumina and too rich in silics to be valuable as a source of aluminium.

Arising out of this, the Secretary pointed out that the term 'Bauxite' is not to be found in the Oxford Dictionary. On the other hand, the term 'Beauxite' is used for this mineral. The mineral was discovered by Berthier in 1821 at Les Baux, near Arles, in France. Berthier did not give a name to this newly discovered mineral, and in 1847 Dufrenoy coined the word 'Beauxite' for the mineral. However, in 1861, H. St. Clair Deville, the father of the aluminium industry, altered the spelling to 'Bauxite'. Apparently this alternative spelling is now accepted.

Mr. A. L. Meston delivered an illustrated lecture on 'Some new aspects of Tasman's visit in 1642', of which the following is an abstract:—

> The boats commanded by Pilot Major Visscher, which left Tasman's ships *Heemskirk* and *Zeehan*, to search for wood, vegetables, and water, landed at what is known now as Boomer Creek on the western side of the upper portion of Blackman's Bay, where the monument now at Dunalley should have been built.
>
> He based his conclusions on fresh cartographic evidence, a review of old maps and sketches, a consideration of botanic evidence of journals, and a close study of the topography of the coastline. He illustrated his points with lantern slides and quotations.
>
> The inner lobe of Blackman's Bay would not have been seen from the boats, Mr. Meston contended. The time taken for the journey would have made it impossible for them to have reached there. The only permanent water on shore was in Boomer Creek. Referring to the swimming ashore of the carpenter with the flag on the following day, Mr. Meston said this occurred not in Prince of Wales Bay, as believed, but at the northern end of North Bay.

20TH APRIL, 1943

A meeting was held in the Society's Room on this date. The President, His Excellency the Governor, presided.

The following were elected members of the Society:—Mr. C. N. Hope, Rev. C. C. Robertson.

Dr. V. V. Hickman drew attention to a statement by 'Peregrine' in Nature Notes published in the *Mercury* on the 19th April, and corrected a statement which said that the long-legged inhabitant of dark corners of rooms which spins a web like the spider is not a true spider. Dr. Hickman pointed out that this is a true spider and bears the name *Pholcus phalangioides*. A specimen of this species was shown on the screen and also for purposes of comparison a specimen of the *Phalangides* which children often call 'Daddy long-legs'.

Dr. J. W. Evans delivered an illustrated lecture entitled 'The Life and Achievements of Charles Darwin', of which the following is an abstract:—

> Charles Darwin, though by no means the first man to whom the concept of evolution occurred, was the first to make it credible and to cause it to be generally accepted. He was born in 1809, the son of a country doctor, and after graduating at Cambridge spent four years voyaging around the world on H.M.S. *Beagle*. During these years he had a unique opportunity of studying the fauna, flora, and geology of many countries, including Tasmania. The observations which he made during the voyage, especially those made during the *Beagle's* stay at the Galapagos Islands, raised doubts in his mind concerning the fixity of species. Shortly after his return to England in 1836, he settled in the country at Down, in Kent, where he remained, a partial invalid, for the rest of his life. His best known work, 'The Origin of Species' was published in 1859 and raised a storm of criticism. He also wrote many other books on a variety of subjects, and died in 1882. The last part of the lecture was devoted to a short account of Darwin's ideas on evolution and how they are regarded in the light of present-day knowledge.

18TH MAY, 1943

A meeting was held in the Society's Room on this date. The President, His Excellency the Governor, presided.

The following were elected members of the Society:—Miss C. Jensen, Dr. J. Gunson, Dr. J. B. G. Muir.

A paper, entitled 'Social Life in Van Diemen's Land in the Early Days' was read by Mr. J. D. A. Collier, of which the following is an abstract:—

> The paper took the form of excerpts from letters and journals by early settlers and books by visitors to Tasmania in more recent times, giving the visitors' impressions of the social life and manners of the inhabitants.
>
> Extracts were read from a letter by Mrs. Stephen Adey, wife of the first agent of the Van Diemen's Land Company, who arrived in Hobart Town in 1826. It appeared in a London Sunday newspaper in 1827, also from the Journal of Mrs. Bessie Fenton, wife of Captain Michael Fenton, who emigrated to Tasmania in 1829, and from a number of travel books and sketches written by various visitors at intervals from the early days of settlement up to the visit of Dr. Thomas Wood, author of 'Cobbers', 1939.

Mr. W. H. Hudspeth read a paper entitled 'Early Town-Planning of Hobart Town', which was prepared by Dr. C. Craig of Launceston. This was illustrated by a plan and lantern slides. It is hoped to print this paper in the Papers and Proceedings, 1944.

22ND JUNE, 1943

A meeting was held in the Society's Room on this date. Mr. A. L. Meston, Vice-President, presided.

The following were elected members of the Society:—Mr. S. E. Deegan, Mr. G. Fitzpatrick.

Professor J. R. Elliott delivered a lecture entitled 'Infinity and the Greek Mind', of which the following is an abstract:—

> If we contrast a Greek temple and a Gothic cathedral we notice that the latter has its focus outside itself; it strains upwards after something it cannot express. No Gothic cathedral can be called perfect or even always complete. But the Greek temple contains its own focus, and in such a temple as the Parthenon the perfection of the form was achieved. For the Greek ideals were real and obtainable and could be expressed.
>
> The Greeks had a three-dimensional outlook. They did not fail to encounter infinity or to point out its irrationality. But, as their art shows, they did not admit it to their scheme of things. For it removes the limits within which we are and think. Its entry into the world we known means chaos. It knows no law. It is the magic wand of space and time, and supernatural in any sphere. The Greeks demanded a rational ordered world; they thought harmony the truth of all existence. But infinity is at discord with the finite; it disorders the finite; and reason cannot cope with it.
>
> It is good for us to note the Greek attitude. For most disastrously we have let infinity into the ethical and social sphere. Ideals are not now realisable. No one expects to reach them. The real and the ideal are opposed. And linked with this outlook is the delusion that man inevitably progresses towards perfection, which is however, of course, infinitely distant. But if men put their ideals in the distant future and also believe that man is going to them anyhow a sort of paralysis sets in. They amble along. They take 'steps in the right direction', 'make substantial beginnings', achieve 'strides forward', but they do not expect to get there—that is always for the future. If someone wishes to prevent a reform, he has only to call it an ideal, and immediately the advance towards it will slacken and people will become resigned to approaching it without ever getting it. Means absorb our interest, for the ends which should absorb it are looked on as unattainable.
>
> This is no academic matter. Not the least of Hitler's attractions was his promise of immediate relief, of a new order now. He was not going to lay foundations only, but to complete the building in time for his own generation to enter. And on the other side there was democracy meandering to the world it wanted without any expectation of getting there in its lifetime. This need not and should not be. A democracy of free citizens can act swiftly and completely. But like Achilles pursuing the tortoise in Zeno's paradox we take an infinite number of steps to reach a finite end because we do not regard it as finite. We might learn from the ancient Greeks to keep infinity in its place and remember that when we have run 110 yards a single stride of forty inches will give us the tortoise.

20TH JULY, 1943

A meeting was held in the Society's Room on this date. The President, His Excellency the Governor, presided.

The following were elected members of the Society:—Dr. F. C. Robertson, Mr. B. A. Sheppard.

Dr. Joseph Pearson delivered an illustrated lecture entitled 'Concealing Coloration and Camouflage', of which the following is an abstract:—

Colours of organisms may be due to pigments such as chlorophyll, haemoglobin, melanin, etc., to diffraction due to the structural character of a substance (mother of pearl) or a combination of both (scales of butterflies, wing covers of beetles, etc.).

The lecturer proposed to deal mainly with the coloration due to melanin and other pigments in chromatophores of the skin.

Coloration of the body was either temporary or permanent.

Temporary or Changeable Coloration

Chiefly found in crustacea, cephalopods, and cold-blooded vertebrates.

Chromatophores generally found in dermis of cephalopods and crustacea. In cold-blooded vertebrates they may occur in either the dermis or epidermis, or in both.

The chromatophore of the crustacea is a syncytium and generally contains more than one pigment. In cephalopods the chromatophore is a highly specialized organ. In the vertebrates it is unicellular and has a branched structure and usually possesses only one kind of pigment, though different chromatophores contain black, yellow, blue, and red pigments. In its 'expanded' condition the chromatophore is a richly branched structure. In the 'contracted' condition the pigment is concentrated in a small central mass. It is probable that the shape of the cell is permanently branched, but the melanin moves to and from the centre to the peripheral branches in response to differences of light intensity. The melanophores are the most important as they are concerned with changes from a dark to a light colour.

Most experimental work on the physiology of colour change has been done on the vertebrates.

The eyes play an important part in colour change. If a normal animal is placed on a dark background the melanophores 'expand' and the animal becomes darker; on a light background they 'contract' and the animal becomes lighter. These responsive changes do not happen in the dark or if the eyes are removed or masked. Under such conditions paleness results. Cave animals which live in perpetual darkness lose their melanin and are pale in colour.

Mast found that flounders react to pattern as well as colour. If the fish is laid with its body on a black background, but the head, including the eyes, on a white background, the body colour becomes pale. If the animal is placed under reversed conditions the body becomes dark.

Townsend found that certain tropical fishes responded very quickly to changed conditions of background and illumination.

Hogben's classical researches have clarified some of the problems of vertebrate colour changes. He distinguished three different kinds of responses—

(1) *Dermal response*, which was independent of the eyes. Probably the most archaic type in which the melanophores showed a reflex response to the action of light.

(2) *Ocular response*

(a) In darkness no part of the retina is stimulated.

(b) On a black background with strong illumination, only the 'floor' of the retina is stimulated. A reflex stimulation of the median lobe of the pituitary results in the production of hormone B. This reaches the melanophores through the blood stream and causes the melanin to migrate from the centre of the chromatophores to the peripheral branches, thus producing a dark colour in the skin.

(c) On a white background with strong light all parts of the retina are stimulated. As before, hormone B is produced by stimulation of the floor of the retina. The stimulation of the side walls of the retina reacts on the anterior lobe of the pituitary, thus producing hormone W. The action of hormone W over-rides that of hormone B. The result on the melanophores is to cause centripetal migration of the melanin, thus producing a paleness in the skin.

Crustaces show a somewhat parallel ocular reaction and hormones produced in glands at the base of the eye stalk effect the migration of pigments in the chromatophores.

Permanent Coloration

Birds and mammals do not possess chromatophores, but melanin may be present in the epidermis, hair, and feathers.

Low temperatures strongly inhibit the production of melanin. White fur or feathers found in arctic animals not due to presence of white pigment but to absence of melanin.

Arid conditions also inhibit to some extent the production of melanin, hence the neutral colours of many desert animals.

Humid tropical climates favour the production of pigment. Hence the rich colours of many tropical animals.

The white colour of many polar animals and the neutral browns of many desert forms are primarily physiological in origin and are probably not due to adaptive coloration.

The general response of melanophores or melanin granules in the skin to different degrees of light intensity is well established. Melanin production varies in direct proportion to the intensity of light. Hence the upper side of an animal which receives more sunlight is generally darker than the lower side which is not so well illuminated. Moreover melanin acts as a screen for ultra violet rays and probably assists in regulating the body temperature in 'cold-blooded' animals. Many animals have their high lights and shadows neutralized. This 'countershading' has the effect of making a solid animal look flat. This again is primarily the result of physiological reactions rather than a colour response to an animal's background. Thus the colour phases of an animal may have two distinct survival values under natural selection both working independently but along the same lines. Some biologists are perhaps inclined to attach too much significance to the selective value of so-called concealing coloration.

Perhaps the only way to assess the value of colour schemes as protective devices would be to carry out definite experiments in each specific case. Three sets of such experiments made by Davenport (chicks), di Cesnola (praying mantis), and Sumner (Gambusia) proved as far as they went that coloration which fitted with a particular background had a definite survival value.

Distractive Coloration

Examples were given from fishes and butterflies to show how structural imitation and colour markings (e.g., eye spot) might serve to distract the predator from the most vulnerable parts of the body of the hunted animal.

Simulative Coloration

Examples were given (e.g., leaf insect, leaf butterfly, stick insect, frogmouth, etc.) of animals which imitate the appearance of inanimate things.

Disruptive Coloration

Many animals have a distinctive colour pattern which tends to break up the shape of the body. Thayer drew attention to this as well as to the concealment value of countershading. He weakened his case by overstating it and, in some instances, by suiting his background to the characteristic pattern of the animal, thus reversing the natural process. In consequence he laid himself open to criticism, and Theodore Roosevelt, who had considerable first-hand knowledge of wild life, castigated him severely. In spite of this, Thayer's concepts form the basis of modern ideas about the value of concealing coloration, but Roosevelt was probably right in insisting on the value of other protective qualities which are practised by animals in nature, e.g., the faculty of making the best use of natural cover, the art of keeping still, cunning, speed, and perhaps above all, the high development of the senses.

The lecture concluded with a brief reference to Batesian and Müllerian mimicry using as examples of the Batesian type the Ceylon forms *Papilio polytes* which has three polymorphic female types one like the male, and two which mimic *Papilio artistolochiae* and *P. hector* respectively. (These latter may be regarded as models.) Ceylon forms were also given as members of a Müllerian mimicry ring, viz., *Danais plexippus* ♂ and ♀, *D. chrysippus* ♂ and ♀, *Elymnias undularis* ♀, and *Hypolimnas misippus* ♀. The males of the two latter species have a different colour pattern from the females.

17TH AUGUST, 1943

A meeting was held in the Society's Room on this date. Mr. A. L. Meston, Vice-President, presided.

Mr. R. H. L. Roberts was elected a member of the Society.

The Secretary reported to the Society that on August 4th, the date of the completion of ten years of office by the President, His Excellency the Governor, he had sent a telegram to His Excellency. A copy of the telegram and of His Excellency's reply is contained in the Annual Report (p. 236).

Dr. P. A. Maplestone delivered a lecture entitled 'Factors influencing the distribution of certain Helminths'.

14TH SEPTEMBER, 1943

A meeting was held in the Society's Room on this date. The President, His Excellency the Governor, presided.

Mr. E. E. Unwin delivered an illustrated lecture entitled 'Biology and Education', of which the following is an abstract:—

> The lecture, which was illustrated with lantern slides, dealt firstly with the personal experience of the lecturer. Beginning with the background of natural history, encouraged in the Quaker boarding schools in England as a leisure-time pursuit (1891-6), this interest during the University period caused a switch over to biology as a major subject for degree work. Then came the rise of nature study as a school subject (1901-4), at first against considerable opposition. This led to further association with Professor L. C. Miall at the University of Leeds in nature study for teachers, as well as research work. Returning to school teaching the development of biology as a secondary school subject followed, at two English schools and since 1924 in Hobart.
>
> The second part of the lecture dealt with the values of biology as a school subject and the various teaching methods employed.

Centenary Celebrations

(Also see page 223)

12TH OCTOBER, 1943

A meeting was held in the Society's Room on this date. The President, His Excellency the Governor, presided.

About 225 members and guests were present.

Mrs. A. Dowling was elected a member of the Society.

The President, His Excellency the Governor, gave the opening address dealing with the history and work of the Society. (See page 224.)

Dr. G. Mackaness gave an illustrated lecture entitled 'Captain William Bligh's Discoveries in Tasmania'. This lecture has not been printed in the present volume as the paper has been privately printed for Dr. Mackaness by D. S. Ford, Printers, Reservoir-street, Sydney. Copies of this paper may be obtained from Dr. Mackaness. A copy has also been presented to the Royal Society's Library.

The following is a brief abstract of the lecture:—

> Captain Bligh made four visits to Tasmania. The first visit was in 1777 with Captain Cook in H.M.S. *Resolution* when Adventure Bay was visited. Practically nothing is known of Bligh's personal association with Cook, though it is certain that Bligh was responsible for many of the charts made on this voyage.
>
> The second visit was made in 1788 when Bligh was Commander of the H.M.S. *Bounty* (first Breadfruit voyage). On this occasion the same anchorage in Adventure Bay was used.
>
> The third visit was paid in 1792 when Bligh, with H.M.S. *Providence* and H.M.S. *Assistant*, paid yet another visit to Adventure Bay (second Breadfruit voyage).

The fourth and last visit was not an exploratory one, but was occasioned by his hurried departure from Sydney in H.M.S. *Porpoise* in 1809 after his deposition and arrest. This resulted in his visiting Hobart Town and the Derwent Estuary where he stayed for nearly a year and became a thorn in the flesh of Governor Collins.

The lecturer discussed observations made by Bligh and his associates regarding the fauna and flora of the country and dealt with many interesting facts about the aboriginals. He also discussed Bligh's few geographical discoveries in the Adventure Bay area and the errors which Bligh made in wrong geographical identifications and interpretations.

A vote of thanks to the lecturer was proposed by Mr. A. L. Meston, Senior Vice-President, and seconded by Dr. W. L. Crowther, Vice-President, and carried unanimously.

14th October, 1943

A special meeting was held on this date (Centenary Day). Three hundred and ten members and guests attended.

The President, His Excellency the Governor, presided.

His Excellency opened the meeting with an introductory speech (see p. 224). Congratulatory messages, which had been received from various scientific bodies were read by the Secretary (see p. 229).

The President then presented the Centenary Medals to Dr. Mackaness and Professor Ashby (see p. 227).

Professor Ashby delivered an illustrated lecture entitled 'A Century of Ideas on Evolution'. This lecture is printed in full in the present volume (see p. 159).

A vote of thanks was proposed by Dr. Gordon, Lecturer in Botany in the University of Tasmania, and seconded by Professor Hickman, Professor of Biology, University of Tasmania.

At the conclusion of the proceedings a conversazione was held in the Art Gallery.

16th November, 1943

A meeting was held in the Society's Room on this date. The President, His Excellency the Governor, presided.

The following were elected members of the Society:—Mr. J. M. Counsel, Mr. J. B. Piggott, Mr. N. H. White, and Mr. C. E. Wilson.

The following papers were laid on the table and taken as read:—

1. Some Australian Apneumonomorphae, by Professor V. V. Hickman.
2. Supplementary History of the Society, completing the period 1913-1943, by Miss Somerville.

The following accessions were recorded:—Knopwood Papers, from Miss M. Hookey; a copy of the Melbourne Advertiser, 8th January, 1838, from Mr. W. E. Masters.

A paper entitled 'As we were' was read by Mr. W. H. Hudspeth, of which the following is an abstract:—

The lecturer dealt with various aspects of life in Tasmania in the year 1827 as disclosed in the columns of *The Hobart Town Gazettes* for that year. Among other points touched upon were the following:—Dr. James Ross and his editorial difficulties; The state of Society in Hobart Town; Fashions and habits of the times; Educational facilities; The first Race Meeting in the Colony; The Drink Traffic; First beginnings of the Tourist Traffic; Trials of the Country Settler; Prominent Military Officers and Civilians; State of the Wool and Wheat Industries; The Labour Market; Convicts, Bushrangers, and Aborigines; Lt. Governor Arthur and his influence on the Community.

A discussion then took place on the Society's achievements, its service to the community, and its future policy. After several members had spoken, it was decided that a special meeting be convened in January to discuss the matters which had been considered at the meeting and to formulate proposals which could be placed before the Society.

Northern Branch

Annual Report, 1943

Meetings of the 1943 session, other than the Annual Meeting and Public Lecture, were held in the Lecture Room at the Queen Victoria Museum and Art Gallery.

31st May, 1943

Annual Meeting and Public Lecture

The Annual Meeting for 1943 was held in the class-room, Public Library, at 7.30 p.m. The Branch President, Mr. F. Smithies, presided.

The following were elected officers for 1943:—

President: Mr. F. Smithies.

Council: Mr. F. Smithies (Chairman), Mr. W. R. Rolph, Mr. D. V. Allen, Mr. G. McKinlay, Hon. Tasman Shields, Mr. J. R. Forward, Mr. J. E. Heritage, Dr. R. A. Scott, Major R. E. Smith.

Hon. Secretary: Mr. E. O. G. Scott.

Hon. Auditor: Mr. J. R. Forward.

The Annual Report and the Statement of Accounts were read and adopted; the latter recorded a credit balance of £19 4s. 1d.

The Annual Meeting was followed, at 8 p.m., by an illustrated public lecture, 'The Geographical Distribution of Animals', by Dr. J. Pearson. The lecture was given in the main hall, Public Library; there was an attendance of about one hundred. An abstract follows.

In introducing his subject, Dr. Pearson spoke of the interest attached to the problem of the occurrence of different types of animals in different parts of the world in the light of the theory of organic evolution; and pointed out that with the abandonment of the older idea of the separate creation of each species the necessity arose of finding plausible explanations of the observed facts of continuous and discontinuous distribution. Modes of distribution from an originating centre were passed in review, and their relative importance assessed; the effectiveness of any given agency is obviously closely correlated with the type of animal concerned. Distribution is hindered, or even prevented, in various ways. Thus, terrestrial mammals commonly migrate slowly, and mountains, deserts, and geographical features giving rise to marked differences of temperature in adjacent regions are generally effective barriers; again, the Isthmus of Panama prevents the mingling of those elements of the eastern and western marine faunas that are capable of living only in warm seas; and so on.

After a brief survey of some general principles, Dr. Pearson showed an extensive series of lantern slides. The principal Zoogeographical regions were first delimited, their relationships in former geological times were considered, and the characteristic elements of their present-day faunas were enumerated. With the aid of maps projected on the screen an investigation was then made of some of the more notable problems of geographical distribution presented by specific groups of animals—groups dealt with included ratites, marsupials, tapirs, elephants,

insectivores, edentates, etc. In conclusion, various theories advanced to account for the population by certain animals of land masses now widely separated from one another were outlined, and their relative merits discussed.

28TH JUNE, 1943

Mr. W. R. Rolph presided.

Mr. F. Smithies gave an illustrated lecture, ' The Overland Journey of Sir John and Lady Franklin to Macquarie Harbour in 1842 ', of which the following is an abstract:—

A notable feature of Sir John's term of office was the constant and energetic steps he took to acquaint himself as fully as possible with the potentialities of the Island and the conditions under which its inhabitants lived. A desire to learn at first hand something of the West Coast region led to the present journey—a venture regarded with little favour in some quarters, contemporary newspaper comments complaining of resultant delays in the transaction of State business.

The party comprised Sir John and Lady Franklin (the latter attended by her maid Stewart); Lieut. Bagot, 51st K.O.L.I., A.D.C.; Joseph Milligan, Surgeon; J. E. Calder, Surveyor; O'Boyle, orderly; David Burn; and about a score of carries. Burn, who joined the expedition at the Ouse on 29th March, 1842, wrote a day-by-day narrative of the journey, numerous extracts from which were quoted.

A delay in starting of several weeks after the date originally proposed adversely affected the whole trip, involving the party in a prolonged spell of exceptionally bad weather. Commissariat difficulties were encountered, and special steps had to be taken to secure emergency supplies from several depots. A halt was made at Marlborough, then expected soon to develop into an important town. After leaving Lake St. Clair, where a stay of some days was made, the party as a whole proceeded on foot, Lady Franklin, however being carried in a palanquin by four volunteer bearers, working two at a time in half-hour shifts.

After several considerable delays, the expedition reached the Gordon on 22nd April. The schooner *Breeze* was awaiting them in Expectation Reach. Adverse weather, however, still hindered their progress, and it was a matter of weeks before they were finally able to clear Macquarie Harbour. After leaving the harbour, they were met by the *Eliza*, sent in search of them. In all, the party was absent from Hobart Town for about two months; while perhaps another month, or more, passed before several search-parties were finally reassembled.

Lantern slides from photographs taken by Mr. Smithies, who had himself covered most of Franklin's route, were shown.

26TH JULY, 1943

The Branch President, Mr. F. Smithies, presided.

Mr. H. J. King gave an illustrated lecture, ' Cine Biology ', of which the following is an abstract:—

Mr. King dealt with some of the more recent developments in cine methods as applied to biology. Particular attention was paid to problems presented by small objects, and steps taken to secure moving pictures of Paramoecium, without the use of any ordinary microscopic apparatus, were detailed. The speaker dealt at some length with the methods and apparatus employed in dealing with several actual cases, ranging from mammals through insects to various elements of pond-life, and recounted some very interesting experiences encountered in the preparation of his natural history films.

Mr. King then showed a series of films, the screening of which was accompanied by a running commentary. Subjects of special interest included the following: life history of the damsel fly (an exceptionally fine and complete sequence, with every phase of the emergence of the imago from the nymphal skin effectively shown); the first five weeks of the development of the brown trout; a general series of Tasmanian mammals; reptiles and amphiba (including the recently discovered *Hyla burrowsi*); several spools of life on the seashore (recent additions including a ctenophoran, a crinoid, and several rare pelagic Actinozoa); wild-flowers, comprising, among others, upwards of forty species of orchids.

30TH AUGUST, 1943

The Branch President, Mr. F. Smithies, presided.

Mr. H. V. Rees, of the Department of Agriculture, gave a lecture on 'Pasteurization', of which the following is an abstract:—

Mr. Rees introduced his subject by an historical survey of the use of heat as a means of food preservation, and called attention to isolated pre-Pasteurian developments that not only involved the recognition by various workers of the relevant general principles now commonly accepted, but also included at least one plant in commercial use. Pasteurization is essentially a process for the reduction of the number of bacteria in a medium, and does not aim at producing a wholly sterile condition. It is, in effect, a compromise between no treatment at all, which leaves intact all bacteria, pathogenic and non-pathogenic, and severe heat treatment (such as boiling), which disposes of all likelihood of food-borne disease by the destruction of the total bacterial content, but does so at the cost of destruction also of non-harmful, and probably even helpful bacteria, and of the partial or complete disruption of heat-labile substances.

Dealing in particular with the pasteurization of milk, Mr. Rees discussed the question of the most effective heat treatment, and compared the relative merits of short exposures to fairly high temperatures and more prolonged exposures to lower temperatures. Social problems associated with controlled and uncontrolled methods of distribution were reviewed; and it was suggested that, after a careful balancing of the advantages and disadvantages incidental to pasteurization, the weight of the evidence is in favour of the establishment of a rigidly controlled system of pasteurization of milk, at any rate in the case of urban supply and distribution. In conclusion, the modes of operation and relative merits of some of the more important pasteurizing units now in use were discussed, and illustrations of up-to-date equipment and plants were shown.

27TH SEPTEMBER, 1943

The Branch President, Mr. F. Smithies, presided.

Mr. H. T. Parker, M.A., Psychologist, Education Department, gave a lecture, 'The Evolution of an Environment', of which the following is an abstract:—

Mr. Parker first pointed out that while we are generally accustomed to think of evolution solely, or at least primarily, in terms of its connexion with organisms, there is a logical necessity to inquire also concerning the occurrence of evolutionary processes in the environment. This necessity directly follows from the intimate relationship subsisting between the organism and its environment; to think of an organism completely detached from its environment is to consider a barren abstraction, and we are soon led to conclude that, in the last resort, an organism has full reality and meaning only in its relation to the world in which it lives. Accordingly, it would appear not unreasonable to seek for evidences of evolution in the environment no less than in organisms themselves. Attention was drawn to the increasing tendancy in current biological thought to consider the organism less an isolated unit than as an element in the general pattern of phenomena. Of three readily recognizable stages in the history of biology, the first is that of preoccupation with morphological facts; this is naturally followed by an inquiry into the significance of structures in terms of the functions they are adapted to perform; and, finally, the scope of investigation is extended to include behaviour. There is thus a regular advance towards a more integrated, more fully real concept of the organism as a living element in the general fabric of life.

After briefly tracing the history, both in the evolution of man and in the development of the individual human being, of the successive stages of awareness culminating in conceptual inference, Mr. Parker proceeded to consider in more detail, and with numerous illustrations, the parallel development of the environment in its relation to organic units and processes. In conclusion, some tentative applications of the suggestions advanced to educational theory and practice were briefly considered.

25th October, 1943

The Branch President, Mr. F. Smithies, presided.

Dr. C. Craig, Surgeon Superintendent, Launceston General Hospital, gave an address, ' Some Notes on the History of the Launceston General Hospital ', of which the following is an abstract:—

In the fifties inquiries began to be made into the possibility of building a new hospital in Launceston to replace the old Cornwall establishment; and on 26th January, 1863, the Launceston General Hospital was officially opened on the present site, the cost of the building being £12,000. Accommodation was provided for 74 males and 28 females; at an early period the average daily attendance was 60-70. The fee was 1s. 8d. per day, compared with the present 11s. 6d. In 1868 a separate Invalid Depot was opened in Paterson-street. The original system of administration—a Government-appointed board of six with a chairman—operated till 1871, when full control was invested in the chief medical officer; this arrangement in turn gave way in 1878 to the present method of control by a board and chairman. The first surgeon-superintendent was Dr. J. L. Miller, F.F.P.S. (Glasgow), who held the position from 1863 till 1866. The first matron was Miss Windred, who held office for the period 1881-1884.

With the appointment of Sir John Ramsay the hospital became one of the most advanced centres of research and practice in Australia, and it played a highly significant part in the introduction of the new surgery. Under Sir John's influence an excellent operating theatre (recently demolished) was built in 1906-7. Outstanding landmarks in the modern history of the X-ray section, which has developed so successfully under the guidance of Dr. W. P. Holman, included the initiation of the present department in 1925; the receipt in 1930 of radium and later of radon distributed to selected hospitals by the Commonwealth Government; and the introduction of the deep X-ray plant in 1937.

In the course of his address, the speaker drew attention to the importance to medical science of the knowledge gained from autopsies, and suggested the desirability of amending the present regulations governing them. In most public hospitals, Dr. Craig observed, it is customary to perform post-mortem operations in all instances in which no objection is lodged by relatives within a stated period after death. In Tasmania, State laws require the consent of relatives. The speaker advocated an amendment authorizing the carrying out of autopsies, as a routine practice, in default of a caveat lodged within six hours of death.

Council Meetings

Meetings of the Council were held on 2nd April, 4th May, 11th June, 14th July, 10th August, 23rd November, 1943.

Obituary Notice

Arndell Neil Lewis, M.C., LL.D.

(Nov. 23rd, 1897-Dec. 27th, 1943)

At the time of the Centenary meeting of the Royal Society of Tasmania, although it was noted that Dr. Lewis was not present; his absence was not known to be due to a grave breakdown in his health, army service being assumed to be the cause. At the November meeting, when the question arose as to what were to be the functions of the Society in the future, he spoke and made a number of valuable suggestions, yet it was to be his last public act, as a rapid detoriation of his health set in, and his death occurred two days after Xmas.

Arndell Neil Lewis was a Tasmania of the fourth generation on both sides of the family, Richard Lewis having arrived in the Colony as early as 1812 and his mother's ancestor, the Rev. John Yule (a member of the pioneer group of missionaries to Tahiti), in 1813, when he was appointed as first Anglican Chaplain to the growing settlement at Port Dalyrmple.

Elder son of Sir Elliot Lewis and born on Nov. 23, 1897, A. N. Lewis was reared in an environment that brought him as a child into contact with leading figures of our political and social life. Outstanding among them was R. M. Johnston, Geologist and Government Statistician, who in walks and expeditions gradually inspired in him his own love of geology. He was fortunate, too, that his education at Clemes College was largely from Mr. W. H. Clemes, who was his mentor and life-long friend. It has been said that Lewis who was never attracted to sport, quite early made the request that, instead of having to do his share in them, he be allowed to follow up this science. Be that as it may, when he was about fifteen he brought to an exhibition of school work a remarkable collection of minerals and fossils, classified and described by himself, indicating already his originality of thought and deep interest in natural science. Guided by Mr. Clemes he took geology as part of his leaving examination. The outbreak of the 1914-18 war found him, although only sixteen years of age, with a commission in the Senior Cadets, then an integral part of Commonwealth military training. Until of military age he served in Tasmania and Victoria, and eventually joined the A.I.F. and served in the 1st Fld. Art. Bgde, the arm of his choice. The Armistice found him not yet nineteen years of age with a year's service in France and the M.C. for gallant work as a F.O.O. with an associated American division on the Hindenburg Line.

Following his return to Tasmania there followed a remarkable twenty-five years of devoted work for his community as lawyer, soldier, and scientist. It was

only fitting that he should follow his father's profession of the Law, to which he was admitted as a solicitor to the Supreme Court on 21st July, 1922. He joined the family firm of Lewis, Hudspeth, Perkins, and Dear, of which he was, at his death, the senior member. Graduation as LL.B. in the same year at the University of Tasmania was followed by the higher degree of LL.M. in 1925 and the LL.D. in 1930. At a special convocation in the following year his Doctorate was conferred by his father as Chancellor of the University.

During these years A. N. Lewis published a text-book of Australian Bankruptcy Law, now in its third edition, and used at more than one University. This was followed by a similar work on Australian Military Law, which was in the first place presented as a thesis when he was granted his Doctorate. He edited, too, the Tasmanian section of the Law Reports of Australia, a work that drew sadly on his limited spare time.

It is well known that political life offers perhaps the only road to high legal office, and, again, there was the tradition, both of his grandfather's long thirty years' service in the House, with periods of Ministerial office, and more recently his father's long and honourable career as Premier and Lt.-Governor of the State.

The times, alas, were very different from those in which his forebears took so distinguished a part. For the reverence and, indeed, hero-worship which was the reward of those who undertook public life in those decades, there was now apathy and indifference. Sincere and earnest and always handicapped by his own reticence and modesty he had most difficult elections to fight before his return in 1937. As a Member he was an outstanding figure, and one of the leaders of his party. His last political act was typical, when he resigned his seat feeling he could not carry out his military duties and properly serve his electorate at one and the same time.

As a Trustee of the Tasmanian Museum and a member of the Council of the Royal Society of Tasmania he was prominent from 1925. For the Museum he worked most generously as Chairman of Trustees and in organizing the casing and display of the Petterd and general geological specimens. This latter work took an immense amount of his time and was still unfinished when the outbreak of this war caused him to relinquish it. He was unstinting in the help he gave all aspects of the development of the Institution. On the Council of the Royal Society he was a delightful colleague, wise and generous in thought and action and, as always, a tireless worker. In committee, when such matters as a redrafting of the Society's rules was under consideration, we all turned to him. It was his wise counsel that helped most in the desperate years of the depression when he suggested, *inter alia*, the formation of the reserve fund that has since been so helpful. Above all, he was always to be relied upon with a sustained output of original work contributed by lecture and, when feasible, in full detail as a paper to the Proceedings.

Military service disputed with Geology for what spare time he might have, and in both he delighted. It was again a family tradition to serve in the Artillery, his grandfather and father both having done so, and his uncle Lt.-Col. R. C. Lewis, D.S.O., as commanding officer of the Garrison Artillery. Between the wars he was posted to the 6th A. Fld. Art. Bgde. as Lt.-Col. commanding, 1933-1938. An ideal soldier, he was untiring in his efforts to guide and lead, and most qualified to do so with his practical experience of the essential duties of all ranks. The secret of his success was his affection for the men and his ready accessibility. Able to sleep and live happily under conditions of much discomfort, it was his way to be first out in the morning and still at work long after the rest were asleep at night. By wise leadership he was largely instrumental in the Brigade winning the Mt. Shanck Trophy from all Australia and for years for them to be always one of the

hardest to eliminate in the finals of the competition. He was at his happiest and best on the long three-day treks between Hobart and Ross with his Battery, riding at ease, smoking and yarning he was a fund of information on everything we happened to pass, be it a homestead, trees, animals, anything—he had an anecdote to tell or some information to give as we went along. Most important of all, through these years he was training and preparing a succession of young officers for what lay ahead, and eventually in 1938 he was able to hand over a first-class command to his successor.

For some years there had been disquiet as to his health and on the outbreak of war his services were not accepted for this reason, so for a time he had to content himself with the responsible position as Director of Manpower for the State. To his delight, at a later period, he was given a post of great responsibility in the defence of the Island. To the carrying out of this trust he was unsparing of his bodily strength, and it was only realised late last year that his health had completely broken down, so he came back to civil life for the few months he had to live.

Dr. D. Thomas, Tasmanian Government Geologist, has undertaken to write of the scope and significance of the work done by Lewis in Geology, my own association with what must be looked on as his greatest achievement, is personal rather than scientific. In 1919 he resumed the field work commenced as a schoolboy with the Field Naturalists' Club. His companions were L. H. and A. V. Giblin, W. H. Clemes, C. E. Lord, and M. S. R. Sharland, and with them he ranged widely, especially towards the almost unexplored country of the S.W. Here his splendid physique and endurance were fully called upon as all supplies had to be carried by pack. Finding the existing maps to be quite inadequate he determined, in part at least, to remedy the deficiency. With John Murray he produced a scale map of the country from the Estuary of the Derwent to above Bridgewater with a considerable depth on each side of the river and, incidentally, this map has been of inestimable value to the Military Authority. For the last ten years, in conjunction with all his other works, he set himself the task of filling in the geological outlines of the country included in this map, which gradually was filled in and completion was within sight when war broke out.

His intellect matched his body, slow in making a decision, he reasoned clearly and deeply and was a most original thinker. As a teacher he expressed himself with great clarity and was at his best with young eager schoolboys who would follow his every word and action as he pointed out geological features encountered on an expedition. It was little wonder, as he gave them the same grave courtesy as he extended to the many distinguished scientific men whom he entertained in his home and took afield with him. He had, too, always a very boyish outlook, which they understood and reciprocated. Best of all he was utterly honest in all his intellectual and personal relationships. His family life was ideally happy, with his wife in all ways the good companion, with him when possible in the field, and always at hand with encouragement in his heavy commitments. Perhaps his whole character was best assumed up, when Sir Elliot Lewis on the occasion of his son's marriage some sixteen years ago likened him to Chaucer's Parfait gentil Knight. It is as such that we who knew and worked with him will remember him.

W. L. CROWTHER.

Arndell Neil Lewis, M.C., LL.D.

The Geological Work of Dr. A. N. Lewis

Through the untimely death of Dr. A. N. Lewis, Tasmanian geology has lost one of its most distinguished and devoted exponents.

His earliest contributions to the Royal Society of Tasmania were on Glaciology, and his interest in this subject never diminished. His progress in this study can be followed in his papers on the Glacial Remains in the National Park, the topography of Lake Fenton and district, the geology of Mt. Anne and Weld River Valley, La Perouse Range, the origin of the Great Lakes, on varved shales in Tasmania, Pleistocene glaciation from Mt. Field to Strahan, the correlation of Pleistocene glaciation, to mention but the most important. It needed strenuous physical exertion to secure his evidence in the forbidding mountains of Tasmania and his work was a test of endurance as well as a demonstration of insight and sound deduction.

His work stimulated that pioneering zeal that carried him over the greater part of the Island, but in no instance was there any narrow specialization. His work on glaciation was not confined to the mere recording of local details, as the wider aspects were built up on carefully compiled data, which inspired his work on the correlation of the Tasmanian Pleistocene glacial epochs and deposits with a later and even more intriguing paper on the correlation of the Pleistocene raised beaches and river terraces in unglaciated areas.

He was thus the foremost authority on Tasmanian glaciology and as such he was asked to contribute a chapter on this to Professor Sir Edgeworth David's monumental work of *The Geology of Australia.*

Among his unpublished manuscripts is a general account of Tasmanian Glaciation which ably summarises his views. Moments of illuminating discovery are unfortunately too rare in the experience of most of us, but they reached him when he first discerned the evidence of successive glaciations in Tasmania. This he described as follows:—

'In 1922 (December) I was descending the slopes of Mt. Anne, and, looking over the Huon Valley—whether the evening light or the peculiar configuration of the Frankland Range emphasised the fact I know not—but I was struck with the absolute clearness, on the panorama there unfolded, of the evidence of two distinct and superimposed glaciations, the one responsible for the topography of the Huon Plains, the other disclosed in the tributary valleys leading down from the encircling ranges. The fact of a smaller series of valley glaciers, terminating in piedmont moraines each resting on the older glaciated surface of the wide Huon Valley, was too apparent to be missed. With this clear disclosure in the field, I found the key to the task of reconstructing the history of the Pleistocene glaciation in this Island'.

In his numerous traverses through Tasmania he became interested in the many problems associated with the physiography of the areas and of the origin of the present surface features. His views on the physiography were summarised in his note on the Isostatic Background of Tasmanian Physiography, and also in the Handbook to Tasmanian Geology written for the Hobart Meeting of the Australasian Association for the Advancement of Science—a work in which he was joint author.

A search for the base of Permo-Carboniferous rocks in Tasmania, although unsuccessful, made him examine in great detail the areas in which these rocks outcrop. His interest in these systems is shown by the fact that his first published

work was on these rocks, and this was followed by his Notes on a cliff section near Cape Paul Lamanon, where he described the presence of limestone boulders containing characteristic fossils of this age in conglomerates that had been taken to be the base of this series. He described the Catamaran Coal Field and later recorded the presence of Glossopteris from Cygnet. Most of his published work contains reference to this group of rocks and it was this search for the base of the series which led him to investigate the Tyenna Valley where he studied in detail the older Palaeozoic Rocks. He discovered fossils in these older rocks, had them identified and thereby established beyond doubt the Ordovician age of the Junee Series (and the Caroline Creek Beds) which he instituted to embrace some of these rocks. With his characteristic insight he pointed out that the Junee Series rested unconformably on the Dundas Series which thus must be of Cambrian age. Since then, the age of the Dundas Series has been established as Cambrian, thus substantiating his views that the conglomerates at the base of the Junee Series were not West Coast Range conglomerates.

He was the first worker to recognize that volcanic activity was present in Triassic rocks.

Never did he forget the major aspects of geology, as is shown by his paper on the Pulsating World or the Influence of Earth Movements on Human Development, which he delivered when he was presented with the Medal of the Royal Society of Tasmania as a recognition of his geological researches.

He was called on by outside workers for advice and information on Tasmanian geology, and constant reference to his name shows how lavishly and freely this was given. He was a member of geological committees of the Australian and New Zealand Association for the Advancement of Science, and reported on a wide variety of subjects ranging from glaciation, Cainozoic and Quaternary climates, and on structural and land forms.

His published work represents but a fraction of his researches, much of which will now remain unfinished. His manuscripts on the glaciation of Tasmania have already been mentioned, but probably his greatest work—the Geology of Hobart—represents years of detailed application and painstaking research. The work is in great detail and is illustrated by a map showing the same high standard. There are several other papers and essays as well as a series of books on geological subjects which he had commenced to write.

The list of workers in Tasmanian geology is too short to be viewed with complacency, but it is illuminated with names that will long shine where that science is held in honour and Dr. A. N. Lewis by his work has proved himself one of the greatest in a great company.

D. E. THOMAS.

LIST OF PUBLISHED PAPERS WRITTEN BY DR. A. N. LEWIS

A Preliminary Sketch of the Glacial Remains in the National Park. *Pap. & Proc. Roy. Soc. Tas.*, 1921, pp. 16-36.

A Supplementary Note to a Preliminary Sketch of the Glacial Remains Preserved in the National Park of Tasmania. *Ibid.*, pp. 177-179.

A Further Note on the Topography of Lake Fenton and District. National Park of Tasmania. *Pap. & Proc. Roy. Soc. Tas.*, 1922, pp. 32-39.

Notes on a Geological Reconnaissance of Mt. Anne and Weld River Valley, South-Western Tasmania. *Pap. & Proc. Roy. Soc. Tas.*, 1923, pp. 9-42.

Notes on a Geological Reconnaissance of the La Perouse Range. *Pap. & Proc. Roy. Soc. Tas.*, 1924, pp. 9-44.

Note on a Cliff Section near Cape Paul Lamanon. *Ibid.*, pp. 45-50.

Note on the Isostatic Background of Tasmanian Physiography. *Pap. & Proc. Roy. Soc. Tas.*, 1926, pp. 1-24.

Discussion to Note on the Isostatic Background of Tasmanian Physiography. *Pap. & Proc. Roy. Soc. Tas.*, 1927, pp. 66-67.

A Further Account of the Geology of the Catamaran Coal Field. *Ibid.*, pp. 188-210.

Geology (in collaboration with P. B. Nye). *Handbook of Tasmania*, 1928, pp. 19-48. Aust. Assoc. Adv. Sc., Hobart Meeting.

Note on the Origin of the Great Lake and the other Lakes of the Central Plateau. *Pap. & Proc. Roy. Soc. Tas.*, 1932, pp. 15-38.

A correlation of the Tasmanian Pleistocene Glacial Epochs and Deposits. *Pap. & Proc. Roy. Soc. Tas.*, 1933, pp. 67-76.

Glacial Features in D'Entrecasteaux Valley. *Pap. & Proc. Roy. Soc. Tas.*, 1934, pp. 87-90.

A correlation of the Tasmanian Pleistocene Raised Beaches and River Terraces in Unglaciated areas. *Ibid.*, pp. 75-86.

Our Pulsating World. The Influence of Earth Movements on Human Development. *Pap. & Proc. Roy. Soc. Tas.*, 1935, pp. 1-21.

A Record of Pleistocene Varved Shales from Tasmania. *Australian Geographer*, 1936. Vol. II; No. 8, p. 30.

A Record of Volcanic Activity in Tasmania during Triassic Times. *Pap. & Proc. Roy. Soc. Tas.*, 1937, pp. 31-39.

Note on Pleistocene Glaciation, Mt. Field to Strahan. *Pap. & Proc. Roy. Soc. Tas.*, 1938, pp. 161-173.

Record of Glossopteris from Cygnet. *Pap. & Proc. Roy. Soc. Tas.*, 1939, pp. 95-96.

Geology of the Tyenna Valley. *Ibid.*, pp. 33-59.

Reports of Committees Appointed by the Australian and New Zealand Association for the Advancement of Science

Report on Observations of Glaciation in Tasmania since 1920. *Report A.N.Z.A.A.S.* Vol. XVII, 1924, pp. 85-90.

Report of Glacial Research Committee, Tasmania. *Report A.N.Z.A.A.S.* Vol. XIX, 1928, pp. 95-96.

Report on Cainozoic and Quaternary Climate of Australia. Prevailing winds in Tasmania during Pleistocene Times. *Report A.N.Z.A.A.S.* Vol. XIX, 1928, p. 106.

Report of Glacial Phenomena Committee, Tasmania. *Report A.N.Z.A.A.S.* Vol. XXII, 1935, pp. 461-462.

Report of Committee on the Structural and Land Forms of Australia and New Zealand, Tasmania. *Report A.N.Z.A.A.S.* Vol. XXIV, 1939, pp. 400-402.

Tasmanian Field Naturalists' Club

Geological Notes of Easter Camps, 1913, 1920-22, 1924-28.

Tasmanian Naturalist. Outlines of Tasmanian Geology, 1924, 1925, 1926, 1927-28.

A Topographical Map of the Hobart District, 1936 (in collaboration with J. F. N. Murray).

H. H. Pimblett, Government Printer, Tasmania.

NATIONAL MUSEUM OF VICTORIA

PAPERS AND PROCEEDINGS

OF

THE ROYAL SOCIETY OF TASMANIA

FOR THE YEAR

1944

NATIONAL MUSEUM
13 MAR 1946
VICTORIA

Edited by
JOSEPH PEARSON
and
D. COLBRON PEARSE

PUBLISHED BY THE SOCIETY
The Tasmanian Museum and Art Gallery, Hobart

31.12.45.

Price: Ten Shillings

The Royal Society of Tasmania

Papers and Proceedings, 1944

CONTENTS

	Page
Some Fossils from the Dundas Series, Dundas. By D. E. Thomas and Q. J. Henderson	1
A Critical Review of Tasmanian Graptolite Records. By D. E. Thomas	9
Middle Miocene Limestone from Cape Barren Island. By I. Crespin	13
Middle Miocene Limestone from King Island, Tasmania. By I. Crespin	15
Time Scales in the Development of Tasmanian Physiography. By A. N. Lewis	19
Pleistocene Glaciation in Tasmania. By A. N. Lewis	41
Some Abnormal Conditions of the Reproductive System of the Saltwater Crayfish. By V. V. Hickman	57
New Trematodes from Tasmanian Fishes. By P. W. Crowcroft	61
The Female Urogenital System of the Marsupialia with special reference to the Vaginal Complex. By Joseph Pearson	71
Early Town Planning in Hobart. By C. Craig	99
Government Houses in Macquarie Street. By J. Somerville	109
Annual Report, 1944	115
Abstract of Proceedings	121
Obituary	133

Pap. & Proc. Roy. Soc. Tasmania, 1944 (31st December, 1945)

Some Fossils from the Dundas Series, Dundas

By

D. E. Thomas and Q. J. Henderson

Plate I

(Read 13th November, 1944)

The Dundas Series consisting of black and grey slates, sandstones, grits, conglomerates, ashes, and tuffs has been assigned a Cambro-Ordovician age. The discovery of fossil dendroids associated with fragments of trilobites—the latter, unfortunately, too imperfect for specific identification—enables the age of part of this series to be established with some degree of certainty. The age indicated by the fossils is greater than that determined by previous workers on the evidence supplied by fossils stated to be graptolites. Doubt has been cast on the determination of these fossils as graptolites by one of us (D.E.T.), so that the discovery of other fossils in these rocks is important, particularly as they establish the age of the rocks.

Geology

The fossils were found on the Razorback spur about half a mile east of the deserted township of Dundas, which is six miles east of Zeehan. The geology of this area has been described in official publications by L. K. Ward (1909), A. McIntosh Reid (1925), and in an unpublished report by D. E. Thomas and Q. J. Henderson (1943).

In brief, the Razorback is a spur running south-south-east from Lewis Hill, which is on the eastern flank of Mount Razorback. This spur runs between the Gander Creek on the east and an unnamed tributary on the west, both of which flow into the Dundas Rivulet.

The oldest rocks of the area form the Dundas Series, which is intruded by a large body of ultra-basic rock. The general distribution and relationship of these various rocks is shown in the plan and sections. The structural trend is in a meridional direction, and in the area mapped the ultra-basic rocks outcrop on the eastern side of the sedimentary rocks. Although the ultra-basic rocks are intrusive into the sedimentary rocks, the normal relationship is masked by faulting in this locality. The fault at the junction of the rocks, for the sake of reference, is called the Razorback Fault, but several others are exposed in the various mine openings. The dip of this fault varies considerably, in some places being vertical, in others dipping as low as 50° E. (at No. 1 adit), and in the northern part of the mapped area west from 55°-75°. The fault, as is usually the case, is not a straight line. but has well-marked bends in the central portion, when its course swings from north-west to more northerly.

The alteration that the ultra-basic dyke has undergone is considerable, for, apart from the normal metasomatism generally associated with these rocks, included in the general term serpentinization, there has been extensive development of talc and silicification associated with the introduction of tin-bearing solutions.

The sulphides mainly pyrrhotite with some pyrite and arsenopyrite were precipitated simultaneously with the bulk of the quartz. With progressive crystallization and falling temperatures, the solutions became less siliceous and in the later stages carbonate minerals were deposited.

The fossils are found in the black slates on the western side of the fault, and were first gathered in the dump of No. 1 adit, and then later in the black slates further south. In the dump from No. 1 adit there are thin, sandy beds in which fragmentary remains of trilobites were found. Unfortunately, these are too fragmentary for specific identification, but detailed search in this belt may yet yield determinable forms.

The Dundas Series

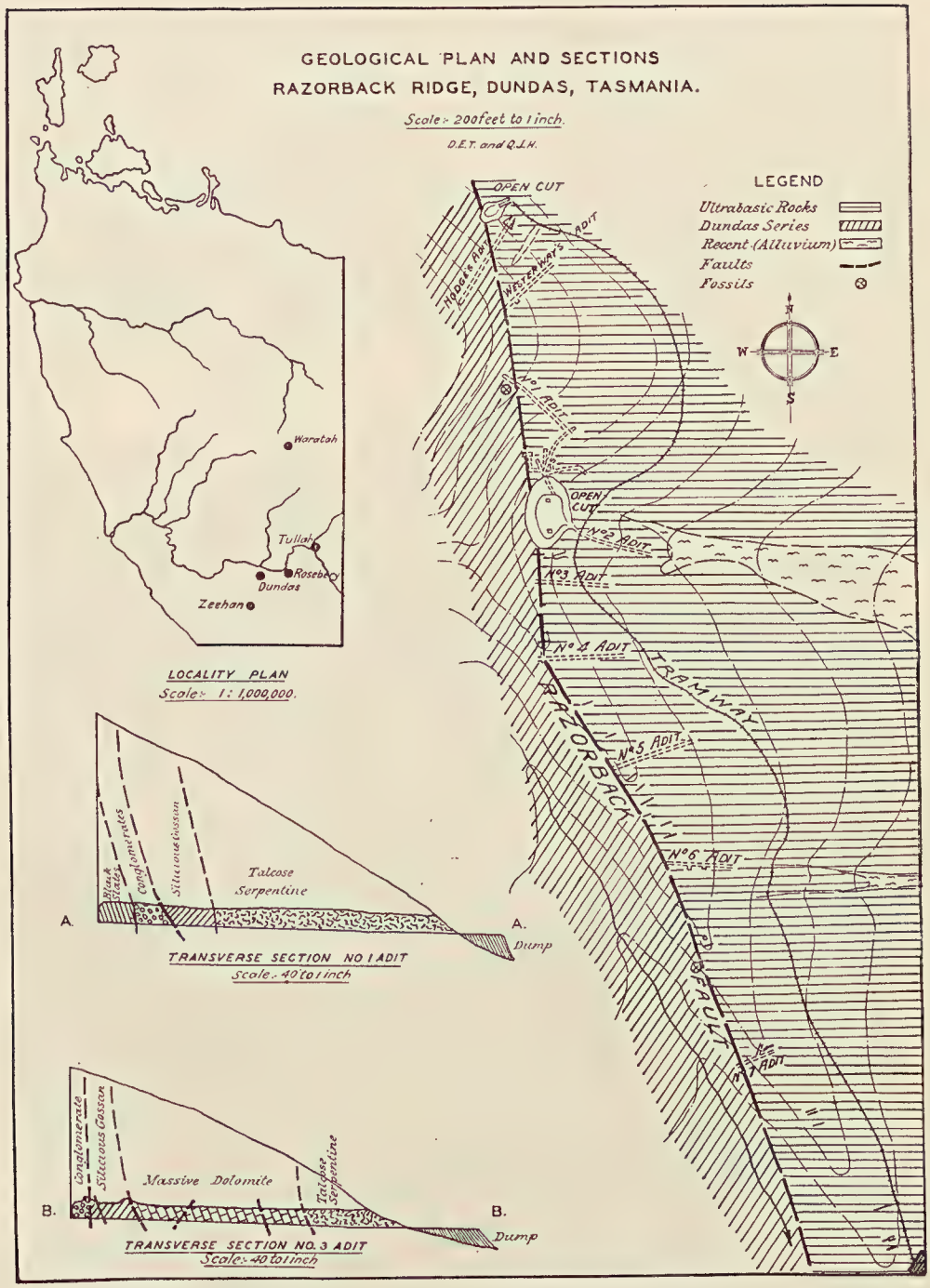
L. K. Ward (1909) used the term Dundas Slates to designate the sedimentary rocks of the Dundas area. 'The greater part of the North Dundas tin field consists of slate, together with the coarser grained sediments—sandstones, grits, and conglomerates. The whole are to be considered as one series, and to them the term "Dundas Slates" has been applied, since the typical rock type is a slate.'

Later authors have used the term 'Dundas Slates' or 'Dundas Series' indiscriminately. In accordance with modern usage, the rock group should be referred to as the Dundas Series. As the Razorback area is included in Ward's original plan of the North Dundas Tin Field, the fossils we are describing were found in the type area and thus fix the age of part of what is undoubtedly the Dundas Series.

Age of the Dundas Series

Faunas similar to that at Dundas have been found in other parts of the world. Of interest are those reported from various horizons below the Tremadocian, i.e., in undoubted Cambrian rocks. *Dendrograptus hallianus* (Prout) is found in the Potsdam sandstone and is an Upper Cambrian form. From the Tempealeau formation of Minnesota and Winsconsin, Ruedemann (1933) has described a fauna which contains *Dictyonema, Dendrograptus,* and *Callograptus* which is associated with a Dikellocephallus fauna, and he describes other Upper Cambrian forms from Tennessee, Vermont, and Quebec. Older than these is (?) *Dendrograptus meso-cambricus* from the Paradoxides Shales from Krekling, Norway, which was described by Opik (1933). Of greater interest are those found in Victoria and described by Chapman (1919), Chapman and Skeats (1919), and Chapman and Thomas (1936). The Tasmanian species are identical with the Victorian and no doubt detailed collecting will add to the number of species that are common to both States. In Victoria, the fauna is associated with two trilobite bands which have been called the Dinesus and the Amphoton bands. These two bands have been included by Whitehouse (1936, pp. 73-74) in his Kootenia Stage, the lowest in the Middle Cambrian. As the Tasmanian forms are identical with the Victorian, there is strong evidence that the rocks are of the same age, i.e., low in the Middle Cambrian.

The table below shows the broad correlation of the Tasmanian horizons with those established in other parts of the world. It should be noted that there has been disagreement between workers as to what should be considered the top of the Cambrian. One of the outstanding geological controversies of the last century was between Murchison and Sedgwick as to the limits of the Silurian of the former and the Cambrian of the latter. Lapworth, in 1879, proposed the term Ordovician as a compromise between their views. While the base of the Arenig, as proposed by Lapworth, has been acceptable to workers on shelly fossils, it has


GEOLOGICAL PLAN AND SECTIONS
RAZORBACK RIDGE, DUNDAS, TASMANIA.
Scale:- 200 feet to 1 inch.
D.E.T. and Q.J.H.
LEGEND
Ultrabasic Rocks
Dundas Series
Recent (Alluvium)
Faults
Fossils
OPEN CUT
HODGE'S ADIT
WESTERN WAY'S ADIT
No 1 ADIT
OPEN CUT
No 2 ADIT
No 3 ADIT
No 4 ADIT
TRAMWAY
No 5 ADIT
No 6 ADIT
RAZORBACK RIDGE
FAULT
No 7 ADIT
N
S
E
W
Waratah
Tullah
Rosebery
Dundas
Zeehan
LOCALITY PLAN
Scale:- 1:1,000,000.
Black Slates
Conglomerates
Siliceous Gossan
Talcose Serpentine
A.
A.
Dump
TRANSVERSE SECTION NO 1 ADIT
Scale:- 40 to 1 inch
Conglomerate
Siliceous Gossan
Massive Dolomite
Talcose Serpentine
B.
B.
Dump
TRANSVERSE SECTION NO. 3 ADIT
Scale:- 40 to 1 inch

COMPARATIVE TABLE OF CAMBRIAN STRATA

	Britain	America	North East Australia (After F. W. Whitehouse) (Faunal Stages)		Victoria	Tasmania
(Now included in Ordovician)	Tremadoc or Shumardia Series	Ozarkian	Asaphellus		Lower Ordovician Lancefieldian	Junee Series and Caroline Creek Beds
			Ellesmereoceras	Ninmaroo Limestones		(Unconformity)
Upper	Lingula Flags or Olenus Series	Croixian	Elathriella Rhodonaspis Glyptagnostus Eugonocare	Pituri Sand tones	Goldie Series	
				Georgina Limestones		Dundas
Middle	Paradoxides Series	Acadian	Anomocare Papyriaspis Phoidagnostus Agnostus Seminula Dinesus Eurostina Amphoton	Templeton Series	Linesus Hydroid Beds	Dendroids and Hydroids Series
Lower	Ollenellus Series	Waucobian	Redlichia Protolenus Archaeocyathus		Heathcote Igneous Complex	

not proved so to those dealing with graptolites, and a number of workers preferred to transfer the uppermost part of the Cambrian (the Tremadocian) into the Ordovician. Mention should also be made of Ulrich's attempt (1911) to recognize two other periods—the Ozarkian and the Canadian between the Cambrian and the Ordovician. The Ozarkian, however, is almost synonymous with the Tremadocian and the Canadian is part of the Lower Ordovician. In the table of correlation the base of the Ordovician is taken as the horizon marked by the incoming of the graptoloid, *Dictyonema flabelliforme*, so that the Tremadocian is included in the Lower Ordovician.

The horizon of the Junee Series and of the Caroline Creek Sandstone is that determined by Kobayashi (1940 *a*, 1940 *b*). As one of the writers (D.E.T.) has found Ordovician fossils in the soft sandstone overlying the conglomerates at Adamsfield, the unconformity beneath the Basal Conglomerate of that district, is taken to be that between the Dundas Series and the Junee Series. This corroborates the views expressed by the late Dr. A. N. Lewis (1940).

Palaeontology

The detailed morphology of the Graptolithina is still a matter of considerable doubt, although during the last decade or so our knowledge of the palaeozoology has advanced considerably. Our lack of knowledge is due to the fact that the forms are extinct, and because their soft parts have left little or no impression upon the chitinous periderm, even when the latter has been preserved. Even with the graptolites, opinion regarding their classification has undergone remarkable changes, which need not be elaborated here, but all these forms are generally included in the Coelenterata. The graptolites themselves are separated from the Dendroids by the presence of a sicula, while the Dendroids have generally a definite stem and a disc of attachment and are characterized externally by their much branched plant-like habit of growth. The stipes of the Dendroids are polymorphic and give rise to a regular succession of budding individuals, bithecae, and hydrothecae. The budding individual, which does not open to the exterior, is a tubular cavity within the stipe and gives rise to the hydrothecae, bithecea, and budding individual of the next generation.

A few dendroids are known in which the rhabdosome originates from a typical sicula with a nema, e.g., *Dictyonema flabelliforme*. As some forms of graptolites, e.g., *Clonograptus* and *Bryograptus*, have a complex thecal structure, it is difficult to indicate the point at which the dividing line between the groups should be placed.

A further complication to the classifications of these fossils was the description by Chapman (1919) of fossil Hydroids. This was based on the external resemblance of the fossils to hydroids of the Campanularid type. Chapman and Thomas (1936) advanced this idea still further when they included *Acanthograptus* with *Cactograptus* in the family Idiidae of living Calyptoblastean Hydroids. The Dendrograptidae were also included in the Calyptoblastea, while *Archaeocryptolaria* and *Archaeolafoea* and several new genera were included in the family Campanulariidae.

Bulman (1937) points out that the detailed morphology of the forms as far as is known is not like that of the living Calyptoblastea and that the genera *Archaeocryptolaria* and *Archaeolafoeia* show a similarity to *Acanthograptus* in the type of development, general habit, and in the possession of tubular and sometimes adnate thecae which confer a 'ropey' appearance to the main axis.

Kozlowski (1938) has published a preliminary paper on a remarkable graptolite fauna in siliceous rocks of Upper Tremadocian age from Wysoczki in Poland,

in which the fossils are in a most perfect state of preservation, the chitinous substance having undergone surprisingly little change. He recognizes two classes, Graptolithina and Pterobranchia. Until detailed descriptions of his new genera are available, we are unable to compare our forms with his, and so adopt the conservative view of considering the fossils from Dundas as belonging to the order Dendroidea.

Genus **Archaeocryptolaria** Chapman, 1919

Archaeocryptolaria skeatsi Chapman

(Plate I, Fig. 1)

A. skeatsi Chapman, 1919, p. 392, pl. XIX, fig. 3, pl. XX, fig. 7.
A. skeatsi Chapman and Skeats, 1919, p. 550, pl. XV, fig. 1.
A. skeatsi Chapman and Thomas, 1936, p. 199, pl. XIV, fig. 3.

Axis slightly curved, 9 mms. long. Hydrothecae about eleven on stipe, suddenly bent outwards at large angles to the main stipe, which is 1/3 mm. wide: maximum length 1 mm.; cylindrical, and only slightly tapering at junction with stem.

Observations. In the figured specimen the hydrothecae are apparently developed only on one side of the main stipe, but a close examination shows that some are bent across the main axis. The general similarity to the Victorian forms is striking. The figured specimen is the only one found sufficiently well preserved for specific identification and is, on Specimen No. 8A, associated with *Mastigograptus* and cf. *Acanthograptus*.

Genus **Mastigograptus** Ruedemann, 1908

Mastigograptus sp.

Hydrocaulus filiform: bifurcating: angle of bifurcation just less than 20°. Total length is 15 mms., of branches 10 mms.

Observations. The form is too slender for illustration, but fragments are common on several slabs. The described form is on Specimen 8B.

Genus **Archaeolafoea** Chapman, 1919

Archaeolafoea serialis Chapman and Thomas

(Plate I, Fig. 3a)

A. serialis Chapman and Thomas, 1936. *Proc. Roy. Soc. Vic.*, p. 201, pl. XIV, figs 9-11, pl. XV, figs 12, 12*a*, and 12*b*.

Hydrosome 30 mms. long, consisting of a slightly flexed axis without branches, the thecae are long, elongately cylindrical, nearly 3 mms. in length spaced somewhat irregularly and give the appearance of arising all round the axis.

Observations. This form is probably the most common in our collections and is indistinguishable from the Victorian forms. The description is of Specimen No. 12.

Genus **Cactograptus** Ruedemann

Cactograptus flexispinosus Chapman and Thomas

(Plate I, Fig. 2)

Cactograptus flexispinosus Chapman and Thomas, *Proc. Roy. Soc.*, 1936, p. 207, pl. XVII, figs 29-33.

Hydrocaulus long, 38 mms., in width of central axis 2 mms., width across the thecae 4 mms. Hydrothecae alternate. Adnate and set at a more acute angle than in *C. crassus*, about 7-8 in 10 mms., bluntly triangular in outline mucronate with flaring apertural margins. The broad middle portion of the hydrocaulus is composed of numerous thecal tubes, as is indicated by the numerous thecal walls.

Material. Specimen No. 5 and counterpart.

Genus **Protohalecium** Chapman and Thomas, 1936

Protohalecium hallianum Chapman and Thomas

(Plate I, Fig. 4)

Protohalecium hallianum Chapman and Thomas, 1936, *Proc. Roy. Soc. Vic.*, p. 204, pl. XVI, fig. 22.

Hydrocaulus short, 15 mms. in length, branching alternately at the angle of the main branch. A grouping of three or four elongate (?) hydrothecae is shown at the terminals of two of the secondary branches, length 2 mms.

Material. Specimen No. 7.

Genus **Sphenoecium** Chapman and Thomas, 1936

Sphenoecium filicoides (Chapman)

(Plate I, Fig. 5)

Sphenothallus filicoides Chapman, 1917, *Rec. Geol. Surv. Vic.*, vol. IV, p. 92, pl. IV, fig. 1.
Sphenoecium filicoides Chapman and Thomas, *Proc. Roy. Soc. Vic.*, 1936, p. 205, pl. XVI, fig. 1.

The length of the available fragment is 4 mms. long, but the specimen is compressed and not well preserved. The thecae 5 mms. in length, elongate, cylindrical in shape and in some cases the aperature is seen as with a cylindrical boundary. The general form of a flaccid stipe and the characteristic thecae are similar to the Victorian forms.

Material. Specimen No. 13 and counterpart.

Sphenoecium sp.

(Plate I, Fig. 3c)

On Specimen No. 13 there is a form which in general shape and characters can be referred to this genus. It differs from *S. filicoides* by being less robust and the thecae are only 1·5 mms. long. Further material is needed before this form can be described in detail.

Genus **Protistograptus** McLearn, 1915

(Plate I, Fig. 3b)

McLearn erected this genus for a simple dendroid that possesses only simple straight or arched cones. The cone is considered as homologous with the sicula of all graptolites. One of these simple forms is present on Specimen No. 12, but there is the possibility that it represents an isolated theca of forms similar to the Sphenoecium sp. mentioned above.

References

Bulman, M. B., 1937.—The Structure of Acanthograptus suecicus and the affinities of Acanthograptus. *Geo. Foren. For handl.* Bd. 59 H.2.

Chapman, F., 1919.—Hydroid remains of Lower Palaeozoic age from Monegetta near Lancefield. *Proc. Roy. Soc. Vic.*, vol. 131, pp. 383-393.

———————, and Skeats, E. W., 1919.—On the Discovery of Fossil Hydroid Remains, etc. *Geol. Mag.*, p. 550, pl. XV.

———————, and Thomas, D. E., 1936.—Cambrian Hydroida of the Heathcote and Monegetta Districts. *Proc. Roy. Soc. Vic.*, vol. 48, pp. 193-212.

Kobayashi, T., 1940*a*.—Lower Ordovician Fossils from Junee, Tasmania, *Pap. Roy. Soc. Tas.*, 1939, pp. 61-66.

———————, 1940*b*.—Lower Orodovician Fossils from Caroline Creek, etc. *Ibid.* pp. 67-76.

Kozlowski, R., 1938.—Les Graptolithes du Tremadoce la Pologne et les portee theoretique. *Annales Musée Zoolog. Polonici*, pp. 183-195.

Lewis, A. N., 1940.—Geology of the Tyenna Valley. *Pap. Roy. Soc. Tas.*, 1939, pp. 33-59.

McLearn, F. H., 1915.—The Lower Ordovician at St. John, New Brunswick, and the new Genus Protistograptus. *Am. Journ. Sc.*, (4) 40, pp. 49-59.

Opik, A., 1933.—Uber einen Kambrischen Graptolithen aus Norwegan. *Norsk. Geol. Tiddskr*, 13, pp. 113-115.

Reid, A. McIntosh, 1925.—The Dundas Mineral Field. *Bull. No. 6, Geol. Surv. Tas.*

Ruedemann, R., 1933.—The Cambrian of the Upper Mississippi Valley. Pt. III. *Graptoloidea Bull. Publ. Mus. City Milwaukee.*

Ulrich, E. O., 1911.—Revision of the Palaeozoic Systems. *Bull. Geol. Soc. Am.*, vol. 22, pp. 281 and 680.

Ward, L. K., 1909.—The Tin Field of North Dundas. *Bull. No. 36, Geol. Surv. Tas.*

Whitehouse, F. W., 1936.—The Cambrian Faunas of North Eastern Australia. Pts. 1 and 2. *Mem. Queens. Mus.*, vol. XI, pt. I, pp. 59-112.

Explanation of Plate I

Fig. 1.—*Archaeocryptolaria skeatsi* Chapman. Spec. No. 8A.

Fig. 2.—*Cactograptus flexispinosus* Chapman and Thomas. Spec. No. 5.

Fig. 3.—*(a) Archaeolafoea serialis* Chapman and Thomas.

(b) ?Protistograptus sp.

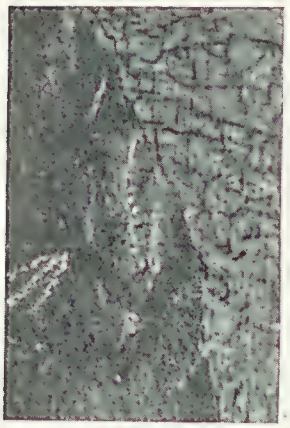
(c) Sphenoecium sp.
Spec. No. 12.

Fig. 4.—*Protohalecium hallianum* Chapman and Thomas. Spec. No. 7.

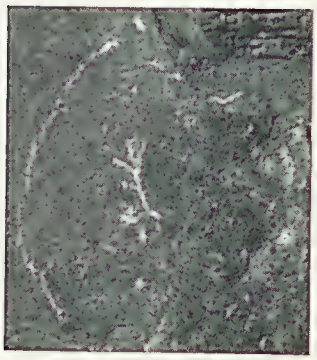
Fig. 5.—*Sphenoecium filicoides* (Chapman). Spec. No. 13.

(All figures are X2)

All figured specimens are in the Geological Survey Collections, Mines Department, Hobart.

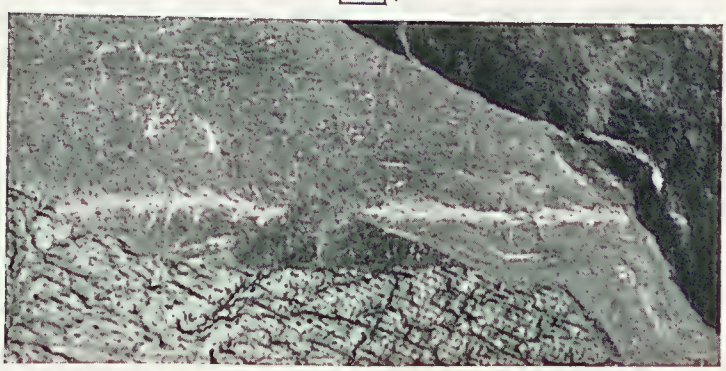


1



4

3



2

5

A Critical Review of Tasmanian Graptolite Records

By

D. E. Thomas

(Read 13th November, 1944)

The discovery of fossils either Hydroids or Dendroids in the Dundas area, which is the subject of a separate paper by Mr. Q. J. Henderson and the writer, led to the re-examination of the graptolite records of Tasmania and all the available material. Three specimens of black slate which previous writers had examined and on which the graptolite record is mainly based, were available for study. One, in the Tasmanian Museum, was kindly lent by the Director, Dr. J. Pearson, and the other two are in the collections of the Mines Department, Hobart. As I was unable to substantiate the identifications of the earlier workers or state that graptolites were present, the specimens were forwarded for examination and comment to Dr. W. J. Harris. He is of the opinion that none of the specimens submitted to him are graptolites.

Previous Literature

G. Thureau (1882), while describing the slates of the Lisle Goldfield, stated that 'incomplete petrefactions *(Diplograpsus nodosus)* were observed resembling, to some extent, the Victorian series of Graptolitidae.' T. S. Hall (1898) gives the result of the enquiries made by him into this occurrence and gives the additional information that Thureau had told him that he ' . . . carried (the specimen) to Strahan and there identified it from memory, no books of reference being available; nor did he at any later time compare it with the figure and description, and shortly afterwards lost it.' The above paper has for its concluding paragraph: 'In conclusion, it may be, it would seem, only reasonable to believe that a Diplograptus was found in Tasmania by Mr. Thureau, and as the range of the genus was so great, that no definite conclusions can be drawn from the occurrence.' T. S. Hall (1902) gave details of correspondence with Thureau regarding the above paper, after its publication. 'I now recollect seeing there (that is, at Lisle, T.S.H.) dark elongated imprints probably carbonaceous—in those dark-blue shales, but they were too indistinct to be classified.' Further on, T. S. Hall quotes this letter again: 'With regard to the true graptolite . . . the locality is about 10 miles from Strahan, on the old Mount Lyell-road (Tas.) close to an old roadmaker's camp and stable, near a spring of water.' Hall then comments as follows: 'This is the specimen which, from Mr. Thureau's conversation, I felt convinced was a *Diplograptus*. Of the Lisle record, I express no other opinion than my belief in its worthlessness.'

From the above, it can be seen that the identification of the Strahan specimen cannot be verified and it should not be accepted as an authentic record.

T. S. Hall (1902) gives further information regarding Tasmanian occurrences, when he states that he saw 'traces of graptolites . . . [from] the North-East

Dundas Railway . . . From the appearance of the indistinct markings present on the stone the specimen belongs to the Dendroidea, and I am inclined to think, to the genus *Callograptus* . . . '

Further on he states that he has seen two specimens of slates in which 'a fragment showing graptolite thecae can be distinguished . . . In neither instance can even a guess at the family be hazarded. We thus have undoubted evidence of the existence of graptolites in Tasmania.'

It should be emphasised here that the above remarks show that dendroids rather than graptoloids occur in Tasmania.

R. A. Keble (1928) examined the three specimens that T. S. Hall mentioned, and stated with regard to the specimen No. 10935 from the Tasmanian Museum that 'I would rather be inclined to refer it to *Retiograptus* than the Dendroidea.'

His list of identifications for the specimens in the Mines Department collection are as follows:—

Dichograptid—fragment
?Tetragraptus sp.
?Leptograptus sp.
?Syndyograptus sp. (distal fragment)—

with the following proviso: 'In this poorly preserved collection not even a generic determination is certain.

The evidence as it appears to me is, then:—

1. Dr. Hall was convinced that *Diplograptus* sp. was obtained by Mr. Thureau from Strahan.
2. The indistinct forms from the King River suggest *Retiograptus* affinity.
3. The *Tetragraptus* 12·35 miles from Zeehan is reminiscent of *T. tabidus* recently described by me from Nelson, New Zealand, where it is associated with *Leptograptus, Syndyograptus, Diplograptus, Retiograptus,* etc. . . .

Summarising the evidence, it would seem that the Tasmanian graptolites are Ordovician, either at the summit of the Lower[1] or at the base of the Upper Ordovician.'

The above determinations of genera and the consequent implications as to horizon have been incorporated in geological literature as if founded on incontrovertible fact, but the discovery of fossils which are of older age in part of the Dundas Series re-opens the question as to whether the graptolite record in Tasmania rests on a sound foundation.

After examining the specimens on which the original determinations were made, I was unable to accept the identification of any of the forms as graptolites. As this opinion is so contrary to that expressed by earlier workers, another independent opinion was sought.

The three specimens were, therefore, sent to Dr. W. J. Harris, who reports, as follows (correspondence dated 12/9/43):—'Three slabs of black mudstone were submitted to me by the Government Geologist of Tasmania for examination. I have to report as follows:—

1. *N.E. Dundas Railway—Tas. Mus.* 10935

I can see nothing that I can identify as definitely organic. The ferruginous markings appear only to outline superficial cracks on the slab, and nothing else seems sufficiently definite to warrant discussion.

---

[1] According to the latest classification the horizon indicated would be now included in the Middle Ordovician of Victoria.

2. 12·35 *Miles from Zeehan-N.E. Dundas Tramway—G. A. Waller* 3/02

The two markings indicated by the numbers (1) and (2) on this slab are almost certainly organic (2 especially) but they represent no characters to enable identification as graptolites to be made.

3. 12½ *Miles from Zeehan* (561)

Similar markings as on (2) above, in greater number, but with no evidence of structure. Possibly algal in origin. This slab seems the most promising as far as indications of where further search might be profitable are concerned.

(Sgd.) W. J. HARRIS, B.A., D.Sc.'

SUMMARY

The Lisle graptolite has not been accepted by Dr. T. S. Hall, although he was prepared to accept the record from Strahan. As the specimen from the latter place has been lost, this record cannot be verified. Dr. Hall suggested that some of the specimens from the Dundas Railway had dendroid affinities and that graptolite thecae were present in others. As some dendroids have thecae outwardly similar to those of graptolites, the presence of thecae of this type does not prove that they belong to graptolites.

R. A. Keble suggested that certain generic forms were present which placed the age of the beds 'either at the summit of the Lower or base of the Upper Ordovician'.

A careful examination of the above material does not substantiate this. Dr. W. J. Harris is not prepared to admit the presence of any graptolites in the specimen he examined.

Any determination of the age of the Dundas Series based on the presence of the alleged graptolites thus rests on a very insecure foundation. While dendroids occur in Tasmania, the occurrence of true graptoloids has yet to be established.

In conclusion, I would like to tender my thanks to Dr. J. Pearson for the loan of the material from the Tasmanian Museum; to Dr. W. J. Harris for his report on the specimens which were sent to him; and to Mr. V. A. Coronel of the Public Works Department, Tasmania, for his photographs.

REFERENCES

THUREAU, G., 1882.—Report on the Mineral Sources and on the Permanency of the Lisle Goldfield. *Tas. H. of Ass. Pap.*, No. 46.

HALL, T. S., 1898.—An examination of the Tasmanian Graptolite Record. *Aust. Assoc. Adv. Sci.*, Vol. VII, p. 401.

————, 1902.—Evidence of Graptolites in Tasmania. *Pap. Roy. Soc. Tas.*, pp. 16-17.

KEBLE, R. A., 1928.—Tasmanian Graptolite Record. *Pap. Roy. Soc. Tas.*, pp. 69-71.

Pap. & Proc. Roy. Soc. Tasmania, 1944 (31st December, 1945)

Middle Miocene Limestone from Cape Barren Island, Furneaux Group, Bass Strait

By

I. Crespin

Commonwealth Palaeontologist

(Communicated by D. E. Thomas)

(Read 13th November, 1944)

In 1935 Mr. F. Blake of the Geological Survey of Tasmania visited Cape Barren Island in connexion with the underground water supply at Franklin Village, which is situated on Sandford Bay in the north-west part of the Island. He collected a small sample of fossiliferous limestone which he forwarded to the late Mr. F. Chapman, who was then Commonwealth Palaeontologist. No examination of the material was made at the time. Recently it came under the notice of the writer, who has made a detailed microscopic examination of it, with the following results:—

The rock is a hard to friable, cream coloured, bryozoal limestone. The residue after washing contains numerous foraminifera and bryozoa, but the majority of the specimens are poorly preserved.

A list of species recognized is as follows:—

Foraminifera. *Textularia sagittula* Defr., *Trifarina bradyi* Cushman, *Sigmoidella elegantissima* (d'Orb.), *Globigerina bulloides* d'Orb., *Gypsina globulus* Reuss, *Planorbulinella plana* (H.A. & E.), *Cibicides ungerianus* (d'Orb.), *Discorbis orbicularis* (Terq.), *Notorotalia howchini* (Chap. Parr & Coll.), *Calcarina verriculata* (Howchin and Parr), *Crespinella umbonifera* (Howchin and Parr), *Eponides repandus* (F. & M.), *E. concentricus* (P. & J.), *Elphidium parri* Cushman, *Amphistegina lessonii* d'Orb., *Operculina victoriensis* Chap. & Parr.

Anthozoa. *Mopsea tenisoni* Chapman.

Bryozoa. *Cellaria contigua* Mc.G., *C. depressa* Mapl., *Vincularia gigantea* Canu & Bassler, *Cribrilina terminata* Waters, *Hiantopora liversidgei* (T.Wds.), *Adeonellopsis clavata* (Waters), *Retepora rimata* Waters, *Spiropora verticellata* (Goldf.), *Mecynoecia proboscidea* (M.Edw.), *Idmonea milneana* d'Orb., *I. trigona* McG.

Ostracoda. *Bythocypris tumefacta* Chapman.

Note on the Fauna and the Age of the Limestone

The fossils are poorly preserved and many of the bryozoa cannot be determined even generically. The foraminiferal assemblage contains species which definitely determine the age of the bed. The commonest species is *Calcarina verriculata*, which is one of the most characteristic forms in the assemblage in the

limestone at Batesford, Victoria. Associated with it are *Planorbulinella plana*, *Operculina victoriensis* and *Amphistegina lessonii*, all of which are common in the Batesford limestone. *Calcarina verriculata* is also present in the same horizon in the bores in Gippsland, Victoria, but is not common in that area.

The bryozoal assemblage is similar to that found at Batesford and generally in the Balcombian rocks in Victoria, as well as at King Island, Tasmania.

The ostracod, *Bythocypris tumefacta*, is a typical species in the Balcombian limestones.

The age of the limestones from Cape Barren Island is Middle Miocene. It is referred to the Batesford sub-stage which is considered a subdivision of the Balcombian stage. (Crespin, 1943.)

References

Blake, F., 1935.—Underground Water at Reservation, Cape Barren Island. *Geol. Surv. Tas. Rept.* (Departmental, typewritten.)

Chapman, F., 1910.—The Study of the Batesford Limestone. *Proc. Roy. Soc. Vic.*, n.s. 22, (2), pp. 263-314.

Crespin, I., 1943.—The Stratigraphy of the Tertiary Marine Rocks in Gippsland, Victoria. *Bull. No. 9, Pal. Ser. No. 4, Min. Res. Surv., Canberra.*

Pap. & Proc. Roy. Soc. Tasmania, 1944 (31st December, 1945)

Middle Miocene Limestones from King Island, Tasmania

By

Irene Crespin
Commonwealth Palaeontologist

(Communicated by D. E. Thomas)

(Read 13th November, 1944)

The earliest reference to Tertiary limestones on King Island, Bass Strait, was made by the late Professor Sir Baldwin Spencer (1888) in an account of his expedition to the Island in 1887. He stated that limestone outcropped at Wickham lighthouse on the north-west corner of the Island and to the south between that point and Yellow Rock; on the east coast, just south of Lavinia Point, and at the Blowhole Creek; on the west coast between Pass and Ettrich Rivers and inland near Porky Lagoon and Fitzmaurice Bay. Debenham (1910) published notes on the geology of King Island, in which he gave a list of fossils determined by W. S. Dun from a limestone outcrop at Seal River. Chapman (1912) described the fossil content of limestones collected by J. A. Kershaw from an outcrop along the bank of the Seal River on the extreme south-east of the Island It is possible that this locality is the same as that recorded by Debenham.

The present collection was made by Mrs. A. J. Adams near her property, 'Avondale,' in the centre of the Island. The locations given for the sample are:—

No. 1 from a well 3½ miles from Mrs. A. J. Adams' property.
No. 2 from the same locality, underlying 14 feet of overburden.
No. 3 from the same locality, underlying No. 2.

Nos. 1 and 2 are cream coloured bryozoal and shelly, marly limestones. The material, when washed, shows the fossils to be poorly preserved. The fossils include foraminifera, echinodermata, bryozoa, brachiopoda, pelecypoda, and ostracoda. The assemblage listed below from these two samples indicates that the limestones are Middle Miocene in age and belong to the basal subdivision of the Balcombian, the Longford sub-stage, a name recently introduced by the writer (1943). Rocks of similar age are found near Marrawah and at Table Cape, Tasmania, in western Victoria, and in the Mount Gambier area, South Australia.

No. 3 is a bluish-grey, weathered to ochreous coloured, bryozoal limestone, which is partly recrystallized. Determination of fossil genera and species is difficult because nearly all specimens are coated with minute facets of calcite, which, in many places, completely replaces the organism.

A list of fossils determined in the samples is given below. This is incomplete because of the poor preservation of many specimens:—

Fossil	Samples 1	2	3
Foraminifera			
Trochammina sp.	x		
Gaudryina (Pseudogaudryina) crespinae Cushman		x	
Lagena favosopunctata Brady		x	
Lagena globosa Montagu		x	
Lagena laevis Montagu		x	
Lagena marginata (W. & B.)	x		
Frondicularia lorifera Chapman		x	
Guttulina irregularis (d'Orb.)		x	
Guttulina cf. *problema* (d'Orb.)	x		
Spirillina vivipara Ehrenberg		x	
Discorbis globularis (d'Orb.)		x	
Cibicides lobatulus (W. & J.)		x	
Eponides concentricus (P. & J.)		x	
Eponides repandus (F. & M.)	x	x	x
Elphidium parri Cushman		x	
Anthozoa			
Flabellum sp.	x		
Echinodermata			
Fibularia gregata Tate	x		
Club-shaped cidaroid spines	x	x	
Bryozoa			
Cellaria robusta Maplestone	x		
Cellaria gracilis Busk	x		x
Cellaria depressa Maplestone	x		
Cellaria rigida McG.	x		x
Cellaria laticella Maplestone	x	x	x
Macropora clarkei (T.Wds.)	x		
Macropora crassatina (Waters)	x		
Melicerita angustiloba Busk	x		
Acanthodesia simplex (McG.)	x	x	
Ellisinidra cylindriformis (Waters)	x	x	
Membranipora argus (d'Orb.)	x		
Crateropora patula (Waters)	x		
Gigantopora cribraria (McG.)	x		
Bigemellaria pedunculata McG.	x		
Adeonellopsis clavata (Stol.)	x	x	x
Porina gracilis (McG.)	x	x	
Porina vertebralis Stol.	x	x	
Smittinella tatei (T.Wds.)		x	x
Smittina elongata McG.	x		x
Smittina seriata Waters	x		
Caberea grandis Hincks		x	
Exochella grandis Canu & Bassler		x	
Prostomaria gibbericollis McG.		x	
Microporella pocelliformis Waters		x	
Schizoporella clypeata Canu & Bassler		x	
Schizoporella bombycina Waters		x	
Gephyrophora marginopora (Reuss)		x	
Menipea innocua Waters		x	
Crasepodozum elongatum Canu & Bassler		x	
Crasepodozum roboratum Hincks			
Aspidostoma airensis Maplestone	x		x
Hippomonella abdita (McG.)	x	x	
Bulbipora areolata McG.	x	x	
Porella denticulata Waters	x		x

Fossil	Samples 1	2	3
Nellia sp.	x	....	....
Velumella depressa Canu & Bassler	....	....	x
Retepora rimata Waters	x	. .	....
Crisia acropora Busk	....	x	....
Idmonea milneana d'Orb	x	....	....
Idmonea trigona McG.	x	....	x
Mecynoecia proboscidea (M.Edw.)	...	x	....
Lichenopora australis McG.	....	....	x
Lichenopora radiata Aud.	. .	x	....
Tecticava schnapperensis McG.	x	x	....
Heteropora nodulosa McG.	x	x	....
Brachiopoda			
Magellania sp.		x	....
Pelecypoda			
Chlamys praecursor (Chapman)	x	x	. .
Ostracoda			
Macrocypris decora G.S.B.	x	...	....
Pseudocythere caudata G.S.B.	x		. ..
Bythocypris reniformis G.S.B.	x	x	....
Bairdia cf. *croskeina* G.S.B.	x	.	. ..
Bairdia sp.	x		...
Bairdia ovata G.S.B.	. ..	x	...
Pontocypris attenuata G.S.B.	.. .	x	...

Notes on the Fossil Assemblage

(1) *Foraminifera* are extremely scarce in samples 1 and 3 and, although fairly common in sample 2, they are not well preserved. The majority of species are not indicative of the age of the beds, but the assemblage generally, together with the typical Balcombian forms, *Gaudryina (Pseudogaudryina) crespinae* Cushman, *Frondicularia lorifera* Chapman, and *Elphidium parri* Cushman, is characteristic of the lower portion of the Balcombian stage and is referable to the Longford sub-stage, recently instituted by the writer (1943).

(2) *Echinodermata* are poorly represented. The small echinoid *Fibularia gregata*, recorded from sample 1, is typically Balcombian. Possibly the most interesting fossils in the collection are the numerous club-shaped cidaroid spines in samples 1 and 2. Chapman and Cudmore (1934) state that they were unable to correlate these club-shaped spines with any of the cidaroids examined, although they were recorded from several localities in Victoria, South Australia, and Western Australia belonging to the Balcombian stage.

(3) *Bryozoa* are the commonest fossils present. Many forms are determinable in samples 1 and 2, but, although sample 3 is composed almost entirely of them, few forms are recognisable on account of the incrustation of calcite. The assemblage is typically Balcombian (Middle Miocene). At the same time the assemblage is more typical of western Victoria and south-east South Australia than of Gippsland (eastern Victoria). *Aspidostoma airensis* is important as a zone fossil. It is characteristic of the Janjukian stage, but it is found ranging upwards into the basal Balcombian.

(4) The only representative of the *Brachiopoda* is a broken valve of a *Magellania*.

(5) *Mollusca* are rare, the only one present being that of the pelecypod *Chlamys praecursor* (Chapman), which is typical of the lower Balcombian in other localities.

(6) *Ostracoda* are fairly common and, though all species recorded are referable to recent species, they are typical of the lowest sub-stage of the Balcombian (Longford) horizon in western Victoria and south-eastern South Australia.

References

CHAPMAN, F., 1912.—Notes on a Collection of Tertiary Limestones and their Fossil Contents from King Island. *Mem. Nat. Mus. Melb.*, 4, pp. 39-53.

————————, and CUDMORE, F., 1934.—The Cainozoic Cidaridae of Australia. *Mem. Nat. Mus. Melb.*, 8, pp. 126-149.

CRESPIN, IRENE, 1943.—The Stratigraphy of the Tertiary Marine Rocks in Gippsland, Victoria. *Pal. Bull. No. 4*, Min. Res. Survey, Canberra.

DEBENHAM, F., 1910.—Notes on the Geology of King Island, Bass Strait. *Journ. Roy. Soc. N.S.W.*, 44, pp. 560-576.

SPENCER, BALDWIN, 1888.—Expedition to King Island, November, 1887. *Vict. Nat.*, IV, Jan.

Pap. & Proc. Roy. Soc. Tasmania, 1944 (31st December, 1945)

Time Scales in the Development of Tasmanian Physiography

By

A. N. Lewis

Plates II-V

Of all branches of Geological research, Physiography has been the most neglected in Tasmania. With the exception of a few observations, such as those by Moore, Gregory, David, and Taylor, published accounts prior to 1920 deal with restricted localities. These are excellent and accomplish their objects, but they do not even together constitute a general survey of the structure of Tasmania as a geographical unit of the earth's crust. P. B. Nye (1921, 1924) geologically surveyed parts of the State on a regional basis. The work has been continued since by the Geological Survey, with contributions from other writers, but is, as yet, very far from complete.

The plain fact is that we have not the necessary data on which to build an accurate appreciation of the structural framework of our island. This paper is merely a record of the writer's observations and conclusions, space not permitting an analysis of previous accounts or the views of other observers.

From the point of view of world geography, Tasmania is important as the apex of the Australian continental mass. Physiographically, Bass Strait is merely a very shallow flooded portion of the south-eastern Australian peninsular wedge inserted between the Tasman Sea and Southern Indian Ocean, both of great depth. The Australian-Antarctic connexion passes through Tasmania-Mills Rise-Macquarie Island to Adelie Land. The recent structural history of Tasmania must reflect the measure of the influence of the southern oceanic basins on the Australian continental mass, and any relative pressures and movements must be reflected in Tasmanian physiography. From the purely Tasmanian point of view, a correct interpretation of physiographic structure is essential in every phase of investigation in which geology can be of assistance.

Nye and Blake (1938) summarize current ideas on all major problems of this subject, and the present paper amplifies certain aspects without materially differing from their conclusions. It is based on more detailed work by the writer along the boundary between blocks showing only Permian and more recent rocks, and which, in the Hobart district, shows the post-dolerite movements in great detail.

The major diastrophic periods must, of necessity, be taken as the primary time indices. These, individually, are all clear, but their mutual relationships and dates are often subjects of conflicting evidence. Confusion has been caused in the past by merely local observations, and errors will be possible until all factors are recorded for consideration in relation to all other factors.

The Tasmanian terrain is, for the purpose of this investigation, classified into divisions as follow (Plate II):—

Western Type

Country in which rocks from pre-Cambrian to Devonian appear on the surface.

This paper and the following paper were written by the late Dr. A. N. Lewis some years before his death and were prepared for publication by Dr. D. E. Thomas—Eds. P. &. P.

(*a*) Areas by low relief from sea-level to 1000 ft. which are characterized by gentle slopes and are frequently covered by Tertiary sediments, or by basalt.

(*b*) Areas of high relief rising from sea-level to 5000 ft. marked by mountain ranges with sharp slopes which are sometimes capped with dolerite.

Midlands Type

Country in which Permian to Triassic rocks with intrusive dolerite appear on the surface, in a mosaic of faulted blocks all worn to a peneplain which has, in places, been subsequently elevated but seldom above 2000 ft.

(*a*) Low relief areas of gentle slopes frequently covered with Tertiary sediments, river terraces, or basalt.

(*b*) Hilly relief—an elevated and dissected peneplain, characterized now by low ridges.

Plateau Type

Country showing a Permian base passing upward into Triassic sandstone and usually a dolerite sill cap with one or more scarp faces and an average elevation of 4000 ft.

Bass Type

Areas of low relief with terraces and raised beach margins, and with flooded areas of relatively shallow water.

Dolerite Intrusions

(Plate III)

The age of these is uncertain from stratigraphical evidence in Tasmania, but may be assigned to the Jurassic period from analogy with the dolerites of South Africa. This may be tentatively accepted, as no Tasmanian evidence disproves this age determination.

These intrusions terminated an Upper Permian-Lower Triassic sedimentation, and were preceded by a volcanic phase (Lewis & Voisey, 1937). No subsequent sediments occur until Tertiary times.

Existing dolerite occurrences are hypabyssal and no eruptive phase persists for observation. No indication of the topography immediately following the dolerite intrusion, is now obtainable.

The only reliable datum for measuring the stratigraphical position of the igneous intrusion is the Permian-Triassic successional junction. This appears to be reasonably constant throughout Tasmania. The Permian base is obscured, except where pre-Permian 'islands' give an unusually high 'false' base, due to overlap, while the summit of Triassic rocks has been eroded.[1]

Dolerite is found as sills at every horizon. It is common between lower Palaeozoic rocks and the lowest observable Permian strata in many localities. Sills 400-700 ft. thick are common in the Permian series, particularly in or just above or below the Woodbridge glacial stage. The maximum occurrences are sills averaging 1600 ft. thick overlying the highest Triassic strata now existing in the vicinity. Chilled margin summits are to be found occasionally, and other mineralogical characters indicate that the erosion of these major sills in their thickest part has not been considerable (200-400 ft. as a rough estimate on the available, but imperfect, data).

---

[1] For actual measurements, see *Coal Resources of Tasmania*, 1922, pp. 5-6, and Plate II, but the thickness of the Ross sandstone in the vicinity of Hobart (1350 ft.) is based on an old error, and must be disregarded. 800 ft. is the maximum, and this is, in general terms, the average for all Tasmania.

The maximum height measured from the Permian-Triassic junction of immediately pre-dolerite sediments is 1700 ft. These sediments were terrestrial deposits of relatively soft rock. Resorting is apparent, and immediately prior to the dolerite intrusion the beds, which now stand 1500-1700 ft. above the Permian-Triassic junction, could not have been much above sea-level. Probably their deposition had been rapid, but Tasmania shows no marine transgression between the top of the Upper Marine (Lindisfarne stage) of Permian age and the dolerite intrusions.

Many areas now show little or no interference by dolerite and the thickness given above of the Triassic sediments have been measured in these areas. The strata in such areas correspond sufficiently closely with that in areas which were affected by maximum dolerite intrusion to postulate the following:—

(*a*) A considerable volcanic activity (all traces now removed by erosion) is highly probable. This may have given a measure of protection to pre-dolerite sedimentary rocks.

(*b*) The top of the existing dolerite, immediately after intrusion, could not have been more than 2500 ft. above sea-level and was probably considerably lower. In view of the preservation of unprotected sediments, it may not have been materially above sea-level.

(*c*) The thickest sills had their sedimentary coverings in the general order of only 200 ft.

It appears that the dolerite was not again covered by marine sediments, as no trace of any now remains, and in view of the wide-spread persistence of Triassic coal measures unprotected by overlying rock, it is improbable that all evidence of a depositional phase and a subsequent erosional phase should have been completely removed.

The dolerite was intruded into an area which had been gradually sinking since Upper Permian times and which had been subjected to erosion since Carboniferous or Devonian times. At most, the thickness of the new rock intruded, excluding any volcanic equivalents which may have been since removed, would be in the order of 2500 ft.

In view of the relatively small amount of erosion, not only of the dolerite sills, but also of soft coal measures standing at relatively the same height (e.g., at La Perouse, Lewis, 1925), I postulate that the tops of the dolerite sills, as we now see them, did not stand much above sea-level until the plateau uplifts, to be discussed later, and, in the absence of any protecting covering, the Jurassic rocks must have been protected from erosion by their low elevation.

Dislocations of Older Rocks associated with the Dolerite due to the Dolerite Intrusions

A mass of basic igneous rock 1600 ft. thick cannot 'penetrate' soft coal measures without causing disturbance. This does not seem to have occurred (Lewis, 1928, pp. 7-8).

In the Hobart area, evidence is accumulating which indicates the widespread faulting of the country, with the dolerite occupying spaces between the moving masses of rock and terminating in a long, straight wall of older rock. These faults often show metamorphic contact with the dolerite, and at the same time indicate vertical movements of about 1400 ft. and horizontal movements of the order of 5 miles. Some evidence, although not conclusive, is forthcoming of differential vertical movements at the same time as the intrusions. There are

examples of small masses of sedimentary rocks 'floating' on the dolerite. Subsequent faulting and erosion complicate this field evidence, and much further checking is necessary before it is possible to give an accurate survey of the mechanism of the dolerite intrusions.

The problem of the mechanism of the intrusions must be solved before we can be certain what has happened since. This problem is difficult and we have not progressed very far towards its solution. In general terms, the explanation which best appears to fit the field evidence is that there was a considerable and rather rapid up-arching of surface rocks associated with an ascending normal basic magma. The earth movements caused splitting of the rocks, which became more pronounced upwards. The magma invaded the lower sedimentary series and the Devonian granites, as sills. In the higher elevations it occupied fractures with sharp edges against more massive blocks of sedimentary rocks and with extensive, but smaller, ramifications on the side opposite the fractures. The nature of the ensuing igneous rock mass was determined first by the quantity of the magma in the locality (this varied considerably) and, second, by the shape of the 'mould' into which it was forced. There were many local upward extensions in the nature of small sills and dykes. Lateral pressure by the magma was seldom exerted. The gravitational pressure of uplifted block varied considerably. The pressure of the causal earth movements cannot be estimated, nor can any movements of subsequent collapse be traced at present, but these cannot be neglected as factors.

I must briefly refer to the controversy between Mr. P. B. Nye and myself on the question of the origin of the dolerite plateaux. Nye's first statement (1921) was elaborated into a general principle by Loftus Hills (1922). The gist of this statement was that the dolerite masses are in the approximate position which they assumed when originally intruded. Mr. Nye has since informed me that he considers that Dr. Hills went too far in this generalization. In 1927 I published my reasons for disagreeing with this view as pronounced by Hills, based on Nye's observations, although not with Nye's record of the field evidence (Lewis, 1927). My suggestion of a possible foundering (p. 14) is obviously erroneous, but otherwise subsequent observations confirm my adherence to the general statements contained in that paper with certain further subdivisions. The conflict of ideas was further elaborated (Lewis, 1928). During the 12 years which have since elapsed, I have come to the conclusion from a continuous study of the problem that Nye was right as to the Midlands plain, but made too sweeping a generalization when he included the plateaux and mountains of the south and middle-west; but likewise, I generalized too widely as to the effects of post-dolerite faulting. In other words, Nye had gathered most of his data from an area not greatly affected by Tertiary block faulting, while my experience was almost confined to areas of great disturbance. The two types, it now appears, present essential differences not to be covered by a brief generalization, as will appear in more detail later. Some degree of post-dolerite disturbance is now recognized (Nye and Blake, 1938), but one of the problems to be solved is the extent and date of the dislocations.

From detailed observations around Hobart, I postulate that dislocations of older rock by earth movements associated with the dolerite intrusions were frequent, but relatively small, in horizontal measurement. I would be surprised if one such influence could be traced over a distance of 15 miles, but 5-10 miles is common. All the thick sills are very high in, or at the top of, the intruded sedimentary rock, and the lower sills can be easily measured in several places. The maximum vertical uplift by the dolerite of any bed is about 500 ft. All traces of such dislocation

as physiographic features has long since disappeared and the only indication is given by stratigraphical correlation.

Subsequent faulting, some rotational and others normal, giving rise to horsts have destroyed the possibility of using the present horizons of the dolerite sills as a means to correlate present physiographic units. The only safe guide is the vertical distance between the chilled margin of either the floor or the roof of the sill as measured from the Permian-Triassic junction. This criterion applied round Hobart shows—

(*a*) There is a sill of widespread occurrence about 400-500 ft. thick some 700-900 ft. below the junction.

(*b*) The main Wellington sill occurs some 900 ft. above the junction.

(*c*) Dolerite occurs between these horizons, but is relatively rare.

(*d*) The sills mentioned do not cover large areas continuously. The lower appears to be most extensive and has been traced over some 250 sq. miles, but the upper appears to be very irregular in shape and distribution. Eastward from Mt. Wellington, dolerite is common as broken outcrops of varying thickness.

(*e*) In some areas where Permian rocks predominate and there has been considerable tilting of sub-blocks, the lower sill has been brought to the surface.

(*f*) The upper sill stands at all elevations from sea-level to 4200 ft. At lower altitudes, it is often covered, or partly so, by Triassic coal measures and sandstones. It is much faulted within the major physiographic blocks and is as frequently exposed by this faulting as by simple erosion.

(*g*) Occurrences of dolerite may be found faulted against a different sill or a different level of the same sill. Therefore, only the most detailed deciphering of the structure of the whole of Tasmania can provide an accurate knowledge of the nature and mechanism of the dolerite intrusions.

(*h*) In my opinion, the plains of the midlands, the coastal regions, and old mature valleys standing not very high above sea-level are physiographically similar to the country just after the dolerite intrusions with only some few hundred feet removed since Jurassic times, but the dolerite capped mountains and plateaux and areas where Permian or Lower Palaeozoic rocks predominate show marked effects of one or more post-dolerite uplifts.

Exposure of Area of Lower Palaeozoic Rocks—their Peneplaination and Origin of Western Type Country

Published reports show a fairly well developed peneplain at the base of the Permian series (see section measurements in Geol. Survey, 1922). Apparent contradictions (e.g., *ibid.*, pp. 33-34, 54, 85-88, and 221) do not detract from this statement. It is probable that low hills existed on this peneplain at the commencement of this sedimentation, but none such showing a relief exceeding 500 ft have been identified. However, this aspect has not yet been investigated.

It appears to me to be a reasonable assumption that Permian-Triassic sediments with some intrusive dolerite once covered the Western type landscapes. I have already discussed this at some length (Lewis, 1939). The reasons for this statement are as follows:—

(*a*) Along the junction zone between the Western type and the Plateau type landscapes there is a mosaic of blocks of Ordovician and Permian rocks

in a faulted relationship. I have described the features at Junee. Similar features occur at the Snowy Mountains-Jubilee Range area, at the junction of the Weld, Arve, and Huon Rivers, Mt. Picton and New River area, Mt. King William and Cradle Mt.-Barn Bluff areas. Here, from north to south, blocks of rock lie alongside each other in such a way that the Lower Palaeozoic blocks must have been elevated in comparison with the Permian blocks, and subsequently each must have been reduced to the same general level prior to an uplift along different lines. This arrangement of adjacent blocks showing, on one hand, over a thousand feet of Permian-Triassic strata separated by a chess-board pattern of vertical faults, is too extensive to be explained by some fortuitous overthrusting or erosion effect.

(*b*) Along the whole north coast is a terrain of low-lying Western type. The relief is not generally high, and there is some evidence of Tertiary uplift. Nevertheless, the same mosaic pattern of older and newer rocks is apparent, although in rather more extensive blocks. The dolerite Triassic-Permian rocks and Ordovician-pre-Cambrian rocks all at the same general level form a basement for the Tertiary rocks.

(*c*) Dolerite occurs on many of the Western mountains. At Mt. Anne and Mt. Wedge it is extensively intruded into Cambrian or Ordovician quartzites. At Mt. Elder and Mts. Sedgewick and Dundas it is in association with Permian rocks overlying Silurian strata. At Cradle Mountain it is intrusive into Triassic and Permian rocks which are associated with pre-Cambrian schists. With the exception of Frenchman's Cap (4756 ft.), the dolerite-capped mountains are the highest in those areas of high-level Western type physiography, averaging about 400 ft. higher than those without dolerite. That represents approximately the thickness of the sub-Permian sill, which appears to be fairly constant where not removed by erosion. These dolerite residuals could not be part of a sill intruded in a physiography resembling that now existing, so that post-dolerite physiographic cycles must be postulated.

(*d*) On the coast west of the mountainous country (Western type (*b*)) there are at least two remnants of Permian rocks, one at Malanna and the other associated with intrusive dolerite at Point Hibbs. The central Permian-Triassic sedimentation or for the dolerite sills over the whole composed of Palaeozoic rocks extending to sea-level.

(*e*) The close association of the Devonian granite terrain with newer Permian-Triassic rocks down the east coast repeats the features described above for that area.

(*f*) Taking the Permian-Triassic junction as the datum line, reasonable evidence is forthcoming of a general pre-Permian peneplaination. There is no necessity to postulate any particular degree of regularity for the Permian-Triassic sedimentation or for the dolerites sills over the whole of Tasmania, although there is no evidence to the contrary as yet forthcoming. It is, however, justifiable to assume that newer rocks once covered to some extent the Western type country.

It is not yet possible to define what happened in immediate post-dolerite times. The evidence points to a lengthy period of quiescence, with the dolerite intruding a flat terrain which marked the end of an era of sedimentation. There is no evidence of subsequent submergence and no proof of marked erosion in immediate post-dolerite times. A low, flat terrain is therefore presumed. Taking the top of

the sedimentary series as only slightly above sea-level at the time of the intrusions (coal swamps existed or had been in existence in the not very far distant past) and the maximum thickness of the dolerite as 2000 ft., it is unlikely that the original top of the sills was more than 2000 ft. above sea-level. As the base of the dolerite to which the above measurements were made is well below the top of the sedimentary series and as the dolerite was seldom, if anywhere, 2000 ft. in thickness, the elevations would probably be nearer 1000 ft.

The first major event after the dolerite intrusions of which we have clear evidence is the elevation of the Western type country. This includes the western third of Tasmania, with a strip along the whole of the north coast. As Tasmania has lost much area by more recent submergence, this Western type may have been the predominant portion at one time, with the Midlands and Plateau type areas as incidental intervening strips.

The reasons for the assumption that this elevation did not precede or accompany the dolerite intrusions are those given above. It is clear that the dolerite could not have occurred where it does in the Western type country under existing physiographic conditions. The only explanation which appears to fit all the evidence is that it occurred at the same level (one or more) all over Tasmania. The level of the occurrences mentioned is that of the Permian-Lower Palaeozoic junction, that is approximately 2000-2500 ft. below the Permian-Triassic datum, which datum now stands at the average height of 1500-2000 ft. above sea-level in the Plateau type area and sea-level to 5000 ft. below in the Midlands type areas, giving the average height of the lower sills at the pre-Permian uncomformity as about 0 to 500 ft. in the Plateau type area and 2000 to 2500 ft. below sea-level in the Midlands type area. The dolerite of Mt. Anne and Mt. Wedge at 4000-4500 ft., Mt. Sedgwick 3000-2000 ft. (approx.), Cradle Mt., Barn Bluff 4500-5100 ft. are correlated with this lower sill. This gives an average elevation of the Western type country as some 7000 ft. above the Midlands type and some 4000 ft. above the Plateau type countries.

The above conclusion is based on an assumed correlation of the dolerites which, although it holds good for all exposed areas of the Western type, may possibly not be universally applicable. That doubt, however, only goes to prove the validity of the proposed correlations of the vertical scale. The alternatives are (*a*) the Western type country was dry land during the Permian-Triassic sedimentation, or (*b*) that it was once covered with some thickness of sediment referable to those periods. The probabilities favouring (*b*) increase in direct ratio to the time from the commencement of the sedimentations, since the dolerite at the end of that time is found where it would be expected if, at the time of its occurrence, there was no differentation between the country types. If alternative (*a*) were correct, it would obviate the necessity of removing some 4000 ft. or so of sediments, but still not account for the existence of pre-Cambrian and Ordovician strata at 4000-5000 ft. elevation not far distant from Triassic strata at sea-level. Some differential movement clearly occurred since the end of the Triassic sedimentation, i.e., the date of the dolerite intrusion. This could not have been other than upward for the Western type country, as otherwise the Permian marine sedimentary rocks would have been deposited many thousands of feet above sea-level. The junction country is clearly faulted. The Ordovician-Permian relationship is not that of more recent deposition of the latter in channels of the former (see Lewis, 1939, for examples). Further, in many places Ordovician rocks now stand at the same elevation as all stages of the Permian-Triassic series. If the western country had been dry land in the early stages of the sedimentation and had gradually subsided, it would have been successively covered by later stages. This has not been the

case, at least to any marked degree, and blocks of newer rocks lie against blocks of older rocks with clear fault breaks with displacements often as much as 3000 ft.

For these reasons, the next major event after the dolerite intrusion must have been the elevation of the Western type country into plateaux, followed by the removal of from 2000 to 6000 ft. of Permian-Triassic sediments and intrusive dolerite (if any) from these areas.

This resulted in a peneplain. It is probable that this presented a rather uneven surface, but was reduced by erosion until variations in elevation were not more than about 1000 ft. It covered the whole present surface of Tasmania. That involves the proposition that at general elevation not considerably above sea-level there existed by the end of the peneplaination the Western type country with granite, Silurian-Ordovician, or pre-Cambrian rocks on the surface and the Midlands plateaux types undifferentated between themselves and with predominant dolerite on the surface at about the same level as the older rocks. It also involves a long epoch of erosion, during which most of the Triassic-Permian covering of the Lower Palaeozoic rocks was eroded. It is not necessary to presume a uniform thickness of dolerite in these eroded beds, and, perhaps, they had little or no protection by this hard rock.

The Western type country may have been elevated to its present height by this series of movements, but it is only necessary, in order to fit in with the evidence available, to presume an elevation in the vicinity of 3000-4000 ft., that is, sufficient to bring the top of the Lower Palaeozoic rocks (bottom of the dolerite sill, if any, below the base of the Permian) on a level with the top of the upper dolerite sill above existing Triassic beds.

The evidence for the subsequent peneplaination is as follows:—

(*a*) There is a general accordance of the mountains of the Western type country with the plateaux. This involves a physiographic reason as the higher Western type mountains stand stratigraphically some 4000 ft. higher than the adjacent plateaux, while the two types are physiographically equal in elevation.

(*b*) For the reasons given above, these mountains did not protrude out of the early Permian sea, and did not escape the dolerite intrusions. It might be argued that the factor (*a*) above was due simply to an elevation in early post-dolerite times followed by normal erosion. However there are unelevated portions of the Western type country along the north coast, in association with the peneplain Midlands type country. Also, there are elevated tracts of Lower Palaeozoic rocks in association with the Plateau type country from Cradle Mountain to the Du Canes. In other words, the three types of country all show the same general level whatever rock type occurs on the surface.

(*c*) The mass of overlying Permian-Triassic sediments could not have been eroded from the Western type mountains as they now stand and left the physiography as we now know it.

(*d*) The western rivers are superimposed streams which do not conform to existing physiographic trends. Some of them must have originated in at a higher elevation.

(*e*) Considerable accumulations of pebbles of Lower Palaeozoic rocks are now to be found in valleys which do not contain any such rocks in their watersheds.

For the above reasons it is postulated that portions of the country were elevated into plateaux some 4000-5000 ft. above sea-level, while the other unaffected portions

remained with elevations not exceeding 1000 ft. The mountains or plateaux formed by this elevation were all reduced to approximately the same level as the unaffected area, thus exposing the older rock. That the dolerite sills and soft Triassic sandstones of the Midlands plateaux type areas were not materially affected, while some 4000 ft. or more of these rocks were removed from the Western type country, is another argument for the assumption that the Midlands type country was not at this stage much above sea-level.

The next problem is the date of these happenings. On this matter, no exact evidence whatever is as yet forthcoming. Putting the date of the dolerite intrusions as Jurassic and the date of the north-western marine sedimentary rocks as Miocene, there is still an enormous time-gap, sufficient for all happenings of which we have any evidence. This western country unlift and its peneplaination occurred prior to the deposition of the Lower Tertiary sediments of the north coast and, although it may have taken place in Cretaceous times, it is considered more likely to have occurred in Lower Tertiary times, and, for reference purposes only, I term these the Lower Tertiary uplift and the Lower Tertiary peneplaination.

Exposure of Areas of Permian Rocks in Predominantly Triassic Localities

A somewhat similar movement, although less extensive, both in vertical thrust and area affected, is to be seen in the Plateaux and Midlands types of country which were not affected by the previously described movements which resulted in the exposure of Lower Palaeozoic rocks. In most cases, the Permian rocks are found at the base of areas of Plateau uplifts. I am not speaking of these occurrences here. There are several areas, the most extensive being in south-eastern Tasmania, south of Latrobe, round Lilydale, and at Preolenna, where Permian rocks outcrop on the surface. This involves the removal of the Triassic covering with any intrusive dolerite which may once have been associated with the Triassic sediments.

Some degree of differential uplift of the peneplained surface must have been responsible for this. Around Hobart, these uplifts are clearly in evidence and faults cut low hilly ridges showing Triassic rocks in juxtaposition to Permian rocks for a vertical height of 700 ft. in places. The only explanation which will fit all the evidence is a slight uplift (less than 1000 ft.) with a subsequent peneplaination, leaving areas of Permian rocks on the same general surface level as surrounding areas of Triassic rocks and dolerite.

The age of this series of movements is doubtful The effects were not nearly as marked as those which produced the Western type country. The movements were clearly post-dolerite in sufficient instances to warrant a general statement to this effect. In south-eastern Tasmania, where the Permian areas are most in evidence in a peneplained relationship with Triassic areas, there is no outcrop of Lower Palaeozoic rock. At Latrobe and Preolenna the Permian areas are included in Western type country, with neighbouring areas of Lower Palaeozoic rocks rising higher than the Permian areas, and the removal of the overlying Triassic sandstone was prior to the Plateau uplift and the peneplaination must have been effected before the Plateau uplifts and Miocene deposition phases, as areas of Permian rocks appear on the surface of the Central Plateau at the same level as Triassic areas, and Tertiary sediments cover both types in the midlands. Where observable, there is no sign in either case of any post-Miocene differential movements sufficient to account for the occurrence of the same level of beds of the two ages—one originally considerably below the other (0-1500 ft.).

There is no reason to differentiate these slighter uplifts from the major one which gave us the Western type country. At most, they can only be a final phase of those movements, and the whole of Tasmania was reduced to one peneplain in pre-Miocene times. In the areas now occupied by the Plateaux and Midlands types country, the surface rock at the end of this peneplaination was mostly dolerite of the upper sills, but considerable areas of Triassic sandstone and Permian mudstone also appeared on the surface. In any case, the original uplift produced very marked differences in elevation in close horizontal relationship. These differences were smoothed out by the peneplaination, giving areas of rocks of different ages alongside each other and divided by fault lines. This is seen everywhere, whatever the age of the rock may be. The general geological mapping is not yet completed in sufficient detail to bring this out. With a complete map, it might be possible to trace the mountains produced by this early uplift, and this might show either that the movement was long continued or proceeded in stages, with erosion proceeding at the same time to give the extremely varied pattern now exposed.

It may be asked whether the Western and Permian uplifts were due to the dolerite intrusions. I do not think that this is possible. Where dolerite occurs in the Western type country it occurs high in elevation (about 4000 ft.), with lower elevations occupied by Palaeozoic rocks, while the dolerite caps are peneplainal residuals with the neighbouring dolerite sills of the plateau country which overlie Triassic and Permian strata. This shows a differential uplift of the two types of country independently of the dolerite intrusion. I have already stated my reasons for the view that the western country had no Lower Palaeozoic rocks exposed as a land surface during the Permian-Triassic sedimentation. This leaves the bare possibility of an uplift subsequent to the termination of the sedimentation and earlier than the dolerite intrusions, giving us our highest surviving Triassic strata. Had this happened, we would have to explain why there is no deposit representing the erosion of some 3000-4000 ft. of strata. In view of the fact that in many places (e.g., Maria Island and Junee) sills of dolerite are to be seen between Lower Palaeozoic rocks and the lowest Permian rocks, it is probable that dolerite intruded widely at this horizon, and such residuals as are now to be seen on Western type mountains belong here. For these reasons, I date the uplift of the Western type country as subsequent to the dolerite intrusions (i.e., post-Jurassic).

In the areas where Permian rocks now occur at the surface in Midlands type country, dolerite sills are almost universally developed. It might be argued whether these dolerite sills did not raise the Triassic strata above them so that in the general erosion the Triassic strata was removed, until a general accordance between Permian and dolerite intrusive into Higher Triassic strata was attained. Some such factor is quite possible, but it is not the whole story. Round Hobart we see the same sill and sedimentary strata now standing at different levels showing some degree of post-dolerite faulting. In other places we see the section broken by small faults and the blocks, including the dolerite sills, tilted in repeating patterns or at angles to each other. Further, we see in a few localities, dolerite intrusive into Permian strata, but the latter passing upward with Triassic strata now standing at the same general level with adjacent Permian beds. For these reasons, I think that there is ample evidence of post-dolerite uplift of limited areas sufficient to have caused the removal of the overlying Triassic strata, while neighbouring blocks of soft Triassic coal measures were protected from erosion by their lower elevation.

The Plateau Uplifts

The Plateaux are the second characteristic feature of the Tasmanian physiography. The Western type mountains are bare or saw-back ridges, in contradistinction to the plateaux which are flat-topped and clothed with vegetation. The dominant cause of the extreme difference—a difference which can be noticed fifty miles away—is the dolerite. The plateaux, as the term is used in this paper, stand at an average height of 4000 ft.—a thousand feet higher than the *average* elevation of the far more rugged western mountains. The Central Plateau is the most outstanding. Southward from this runs a chain of more or less isolated plateaux of smaller area but similar elevation, the King Williams, Wyld Craig, Mt. Field, Mueller, Styx, Snowy, Wellington group, and the Hartz, Picton, Adamson's Peak, and the La Perouse group. In the north-east is the Ben Lomond Plateau extending northwards to include Mt. Barrow and Mt. Arthur, Ben Nevis, and Mt. Victoria. Round the flanks of these plateaux are dissected remnants of lower elevations, called tiers and including the indeterminate 'Eastern Tiers'. These features will be discussed later, but they must be closely associated in origin with the higher plateaux.

Starting with the higher plateaux, we appear to be on safe ground in postulating an original peneplaination with the western country, followed by an uplift of both. Physiographic evidence to be discussed later confirms this. The primary problems relating to the plateaux are—

(*a*) Are they uplifts from the general elevation of the midland country or is the latter a rift valley or other subsidence?
(*b*) Are they of more recent date than the Western type mountains?
(*c*) Are the breaks and gaps due to uplifting movements or to normal river erosion?
(*d*) What is the relationship of the plateaux to the surrounding tiers? Has there been one uplift or several, and has any of the movement been subsidence?

These problems will be open for discussion until the whole State is adequately mapped. At present we know practically nothing of the actual structure of the plateaux or their morphology.

The stratigraphy of the plateaux is most regular. In most cases the platform rocks are obscured by faulted blocks, and the lower level of the actual plateaux are Upper Permian strata of or above the Granton stage. At about 1500 ft. this passes into Ross standstone, and from 2500 ft. to 4000 ft. there is a dolerite cap. When a height exceeding 4000 ft. is reached, the above sequence shows further uplift. In places the dolerite cap is thinner or does not exist. This does not appear to affect the general accordance materially nor the average stratigraphical sequence, the place of the missing rock usually being taken by coal measures which normally overlie the Ross sandstone and were predominately invaded by the dolerite.

I regard the plateaux as uplifts from a plain of general low elevation which was of more recent date than the uplift which exposed the Lower Palaeozoic rocks of the Western type country. The landscape and structure imparted by the plateau uplifts was much what we now see, that is, there were breaks and gaps in the plateaux from the first. There was also differential uplift imparting different levels to adjacent blocks.

As compared with the Western type country the Plateau type country stands some 3000-4000 ft. higher stratigraphically, but at approximately the same elevation. Along the junction of the west Plateau type country there is an intricate pattern

of Lower Palaeozoic rocks and Permian-Triassic-dolerite series, all equally affected by the uplift pointing to the earlier western country uplift as already described, followed by a general peneplaination, and this, in turn, followed by a general uplift which includes both the Western type and the Plateau type areas.

Along the western section of Tasmania we have a number of rivers, particularly the Huon and the tributaries of the Derwent, which rise at low altitudes in the Western type country and cut through the plateaux. We also have the Gordon and Pieman, which rise in the plateau and cut through the western mountains. All these streams are antecedent at last in part of their courses.

Factors to be described in more detail later point to the conclusion that these rivers started their present life history in a since removed Permian-Triassic terrain above the Lower Palaeozoic rocks in which they flow. These rivers have worn gorges 1500 ft., nearly sheer, and often 3000 ft. from the top of the mountains without exposing Lower Palaeozoic rocks in the plateaux country. They rise in very mature western valleys and flow through gorges in the plateaux which show all the features of extreme youth. I postulate that they have been stable in the western country for a much longer period than that during which they have been eroding the gorges through the plateaux. Therefore the western uplift antecedes the plateau uplift. Since then there has been river erosion of normal development, accompanied by the removal of the more recent rocks over the Western type country and the erosion in performed courses through to the underlying Lower Palaeozoic rocks.

Along the north coast the Western type country forms a fringe to the plateaux, somewhat comparable, but lower than the wider area of the west coast type. The rivers here rise in the plateaux and flow northward. The general aspect of such rivers as the Forth, Mersey, and Ringarooma appear to have little reference to the Lower Palaeozoic rocks, but to indicate an origin in the plateaux and a subsequent development across the Western type country—again indicating the uplift of the plateaux at the date subsequent to the exposure of the Palaeozoic rocks. In other words, although the two systems show contrary features, one set of features is seen in rivers rising in Western type country and flowing through plateaux, the other set by rivers rising in the plateaux and flowing across Western type country. Both these sets show the features to be expected if the plateaux were of more recent origin than the Western type country.

For these reasons, as well as subsidiary ones to be mentioned later, I postulate that the elevation of the Western type country and the initiation of the present drainage over that portion of the State preceded the elevation of the plateaux.

Turning now to a comparison between the Plateaux areas and the Midland type country, the possibilities are either the subsidence of the Midland type after the initial elevation of the plateaux, or the elevation of the plateaux while the Midlands type country is more or less at a standstill. I favour the latter alternative for the following reasons:—

(*a*) The Midlands type country is largely covered by deposits approximately referred to the Miocene or later periods (but the earlier ones are the only ones that concern us here). Some of these extend below sea-level. If the Midlands type country was formed by sinking, this differentation must have taken place in pre-Miocene times. If the plateaux were due to uplifts, the period of elevation could have occupied a much more extended time (i.e., before and after the deposition of these sediments over the lower country). If the Midlands type country was a submergence the Western type country was first uplifted, then followed by the Plateaux and Midlands type uplift, before the sinking prior to

the Miocene deposition. Such is possible. Evidence of the rivers which cut the plateaux indicate that these valleys were cut prior to the deposition of Miocene sediments. They must have been flowing in their present channels before, during, and after the plateaux uplift, and they emerge on the Midlands type country in their lower levels. Had the latter been due to sinking we would have thought that the rivers had cut an appreciable depth of their gorges through the plateaux previous to the Miocene times. Then, after the deposits were formed in the lower elevations, the river erosion and the deposition was very materially slowed down. In other words, such an interpretation involves a time spacing which does not seem to fit the facts. The Miocene and subsequent deposits only appear in lower elevations (except at Bischoff) and so could not have been deposited prior to the differentation of these physiographic blocks.

(*b*) Had the original level been that of the present plateaux tops the rivers would have cut out valleys from sea-level first. This should have involved gorges in the order of 4000 ft. deep at the then plateaux edges. The sinking of the Midlands type country would have submerged the gorges. There is no evidence of any such gorges. The Midlands type country is not simply due to normal river erosion, as is amply proved by the comparative stratigraphy of the two types, where adjacent. The plateaux show Permian rocks to an average height of 1500 ft., then Triassic and dolerite to 4000 ft. The Midlands types show at sea-level to 600 ft. the rocks which occur on the plateau at 4000 ft. Some faulting must have occurred at some time. Although the evidence is not very clear, I consider it to point to the fact that the faulting gave the upward differentation of the plateaux areas from a general peneplain, as the higher elevations show a peneplained surface which could not have originated *in situ* and the lower elevations show no evidence of a submerged topography of a previously elevated tract of country.

One of the problems of Tasmanian physiography is to decipher what do the 'plateaux' imply. These will be analyzed in some detail later, but here I indicate the view that their only constant factor is their 4000 ft. height. The Central Plateau is too broken to be regarded as a single, simple physiographic unit and probably consists of a number of inter-related blocks. The Mt. Field-Mt. Wellington-Picton-La Perouse group of plateaux show a general accordance at 4000 ft., but are separate physiographic entities. The Ben Lomond plateau shows some of the features of both the other types, but is not exactly in accordance. Even taking these major divisions it is difficult to fix boundaries. The Central Plateau merges south-eastward by a series of steps and shelves to lower plateaux with general levels about 2500 ft. and 1500 ft. The Eastern Tiers do not show the features of the 4000 ft. plateau levels, but correspond closely with the 2500 ft. and 1500 ft. features.

The 1500 ft. plateaux features connect the Mt. Wellington-Mt. Field group with the Eastern Tiers. In the western country the 2500 ft. plateau is much in evidence, but the 1500 ft. is not apparent. Bench marks at lower levels correspond with these of the Midlands type country. Outside the plateau country the 1500 ft. level is a constant factor.

It seems to me that the 1500 ft. level is reasonably universal and the 4000 ft. level is the usual elevation of the areas here called the Plateaux. Below 1500 ft.

we have a series of bench marks which indicate (or perhaps will provide data to indicate) earth movements during the later phase of one period, as the physiography at this level is primarily dependent on geological structure.

The Mechanism of the Uplifts

The possibilities presented by the field evidence are—

1. A relatively early uplift by differential sinking and considerable erosion.
2. A long, continual, gradual uplifting movement, probably in stages.
3. A series of differential movements, giving rise to more or less isolated mountain ranges, followed by a general uplift with some small negative movements.

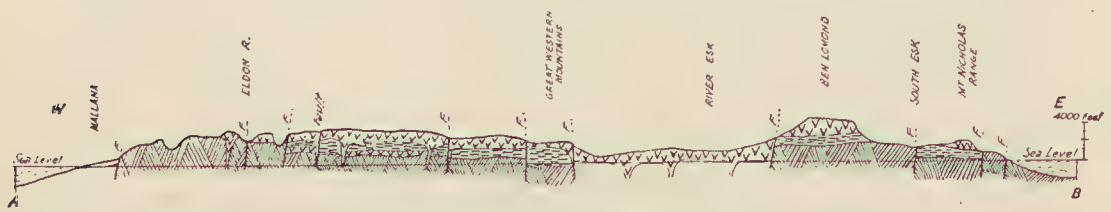
I favour the last alternative at present.

The mechanism of the plateaux uplifts is very much confused by the fact that the terrain upon which the impulses operated had already been faulted. It is now difficult to differentiate the faults caused by the more recent uplifts from those that were previously present on the peneplained surface. In general, the latter movements still leave visible physiographic fractures, and the effects of the earlier ones have been practically removed by the subsequent peneplaination.

From studies on Mt. Wellington, confirmed in a general way by more casual observations on Mt. Field and the Central Plateau, I postulate a series of roughly east-west compressional stresses. These broke the peneplain in roughly north and south directions and elevated long, narrow strips of country. These blocks in turn broke along east-west lines, leaving relatively narrow gaps in the elevated country, and an elevated strip along the line of junction with the Lower Palaeozoic rocks. Pressure was considerable here and some degree of overthrusting, high tilting, and crushing of the newer rocks is apparent.

The resultant elevations consisted of an assemblage of blocks shaped rather like great trichnic pinacoids with their long axis roughly north and south, welded into a physiographic whole but actually separated by major structural faults, now marked by the valleys of important rivers, while the plateaux edges are all marked by a complicated cross-fault pattern. In addition, there is clear evidence of a slight rotational movement imparting a westerly dip averaging 5-10° to each of these subsidiary blocks and a repeating physiographic and structural pattern from east to west through the whole plateau.

Ben Lomond Plateau, the only extensive area over 4000 ft. east of the midlands plains is an exception in that here the pressure appears to have come from the opposite direction from that which produced the other plateaux. Ben Lomond Plateau has Lower Palaeozoic rocks to the north and east, but the other plateaux have the older rocks to the west.



GENERALISED SECTION A-B
TO ILLUSTRATE RELATIONSHIP
OF ROCK GROUPS OF TASMANIA

Scale 0 10 20 30 Miles

Dolerite Permian Triassic Rocks Older Palaeozoic Rocks

J.S.D

The directions of the pressure can only be assumed, but field evidence imparts the suggestion that this pressure which elevated the plateaux came from the areas now occupied by the lowest midlands country. This fact is significant and justifies the proposition that the pressure came from outside the present confines of Tasmania by a sinking of the sea floor. This pressure was exerted on areas of Lower Palaeozoic rocks now fringing the east and north and western coasts and was imparted to the Lower Palaeozoic platform of the central part of the island. This platform gave way and the areas now represented by the plateaux were elevated by a movement mainly vertical, but also slightly rotational away from the more stable areas which remained stationary or were slightly depressed and which now are seen as the Midland type country. In this process, Tasmania lost much land round its coast by direct depression.

What we can see to-day is the surface effect only of a slight shortening of the earth's crust under Tasmania. This may have been so deep seated as to cause folding at a depth, and the physiographic features we see now may only be the surface effects of such folding. On the other hand, the pressure may have been more superficial and have directly affected the surface. The results, however, are clearly the consequences of compressional movements. It is clear that these movements were very gradual and only produced their maximum effects on long, narrow blocks. General uplift or depression movements affecting the whole island produced minor effects. There appears to have been a rythmic result either from one side or the other, or more probably from the centre outward, and the field evidence points to the maximum effects having been produced early, with a gradual lessening.

An alternative possibility is that the whole island was raised by the first effects of this pressure to about 1500 ft. Later, as a final phase, certain blocks were more rapidly raised to 4000 ft. and certain other blocks depressed to about 600 ft. In view of the effects of erosion, to be discussed later, it is impossible to isolate any direct depression of large areas for an elevation of more than 100 or so feet, excepting the Bassian type off the coast which must have sunk.

However, although I regard the movement in general to have been upward, there is no reason to exclude the possibility of differential collapse of strips of country round the edges of the plateaux.

Valley Erosion, Dissection of Plateaux, Deposition of Tertiary Sediments, and Basalts

The next happening in chronological order was the moulding of the details of the landscape from the framework imparted by the tectonic movements already outlined. It is very difficult to determine, except in detail, how much of the present topography is due to either of these influences, but in certain places very considerable gorges have been cut into the plateaux edge. It is clear that—

(*a*) The uplift has been sufficiently gradual to permit most of the rivers to adjust their courses without serious diversion.

(*b*) The uplift took place in more than one stage.

(*c*) There has been a final stage of relatively small throw (600 ft. max.) in post-glacial times which has imparted recent rejuvenation to many rivers.

(*d*) The main valley features were excavated before the deposition of the Tertiary sediments.

Tasmania is a country of wide, flat, mature valleys flanked by precipitous residuals of the older peneplain, but this general statement must be qualified by noting that rejuvenation has interrupted the cycle in many places to such an extent that the erosion cycle is anything but mature in the valley troughs. The problem of this rejuvenation is closely associated with the problem of the 'tiers'—1500 ft. and 2500 ft. plateau residuals.

I postulate a fairly general uplift as already described, by section from west to east or from east and west alternately towards the centre. The western country is pre-eminently a land of mature drainage (interrupted by glaciation and slight uplift), and all the field evidence points to a far longer cycle of river erosion there than in the plateau country. The midlands country is likewise, in general, and subject to rejuvenation, an area of extreme maturity. The real problem arises in regard to the plateau areas. The midlands and western country all correspond approximately, and it is safe to postulate a cycle of approximate duration for both. Of course, maturity has been reached nowhere. The main valleys are wide and extremely flat, but are bounded by steep elevations, and many of the smaller tributaries are mere mountain torrents falling off the uneroded residuals. Speaking broadly, it can be reckoned that the cycle from the original peneplain to full maturity over the whole island was about one-half completed.

The real problem of the dissection of the plateaux is whether all or most of Tasmania was elevated and the midlands country was subsequently carved out to maturity by normal river erosion or whether the plateaux were elevated subsequently to the peneplaination of the midlands country and out of a mature peneplain. The difficulty of reconciling all the field evidence together has led to the violent swing of opinion traceable through Tasmanian geological literature.

My present view is that the truth lies between these alternatives. In brief—that the first uplift was to the 1500 ft. level, and out of the plateau this formed a normal course of river erosion and has produced the Midlands type country as we now see it. Subsequently, and after a considerable interval, the plateaux were elevated. This movement only affected a portion of the country elevated to the 1500 ft. level, and successive stages can be traced at 2500, 3000, 4000, 5000 ft. Each successive stage affected a progressively smaller area within the previous uplift. Usually the later uplifts elevated a block, two sides of which corresponded to portions of two sides of the earlier and more extensive block, so that the maximum elevation from Midlands or Western type country to the highest portion of any particular plateau is continuous on two sides of the highest segment, while elsewhere the successive stages are apparent. In some cases (only the smaller plateaux) the whole block was successively elevated over approximately the same area by each uplift and the earlier stages are apparent not as 'tiers' or subsidiary plateaux, but merely as shoulders on the spurs of the plateaux which we see to-day.

The reasons for this view will be given later in sections dealing in more detail with areas which supply useful data. As a general statement, it is here sufficient to say that the midlands areas do not show a disturbance exceeding 600 ft. since Tertiary sediments were deposited, and mature valleys were even then in existence.

The oldest basalts were younger than the oldest Tertiary deposits. The degree of erosion in basalt terrains on the edge of several plateaux indicates that there has been a considerable uplift (at least 1000 ft.) since the eruption of the oldest basalt, i.e., since the erosion of the mature valleys of the Midlands type country. In close juxtaposition there are plateaux showing sharp escarpments, and Midlands type country covered with Tertiary sediments. These escarpments occupy long

stretches, and are hardly effected by river erosion, i.e., they are not the result of the cycle of river erosion which has produced the mature valley alongside, and so must be the result of a more recent uplift.

But very deep and long entrenchments into the plateaux have been cut by the main tributaries of the larger rivers. The gorges in many places merge into the Midland type country and show very long-continued erosion. It appears to me that this is quite natural. The rivers excavated valleys in the 1500 ft. plateau, and what are now the main rivers continued to excavate their valleys while certain sections of the watershed suffered further gradual elevation. Pre-existing rivers cut into this giving a rejuvenated gorge. Thus we see the sharp interruption occurring often in the middle of a mature river valley (although now at different elevations) and the tributary system persisting, notwithstanding the remarkable gorges met in places. This view also explains the tiers, the lower plateaux, and the topography of south-eastern Tasmania, where the 1500 ft. plateau is very much in evidence, but no higher plateaux have been produced.

The uplifts, at least as far as the 1500 ft. plateau, preceded the deposition of Tertiary sedimentary rocks which are now found solely in valleys eroded in the uplifted plateaux and Western type country, i.e., in the Midlands type country. It is clear that there has been much erosion and resorting of these sediments, and at present we cannot say that the Tertiary deposits did not cover the plateaux prior to elevation. The most we can say is that they are not found on the plateau sides or, except in tiny patches from which no stratigraphical data has yet been gleaned, on the plateaux tops. The point is of great importance, as some Tertiary beds contain fossils and beds which provide a lithological correlation. The question is whether these beds were formed prior to the plateaux uplift or later than this event. The palaeontological evidence supplied by the Tertiary fossils would date the uplifts, but unfortunately reliable data for this correlation is not yet to hand.

The Tertiary deposits themselves have been most admirably described by R. M. Johnston (1888), to such an extent that little further details have been accumulated in the 50 years which have elapsed since his work. Practically no work has been done on these rocks since then.

Johnston recognized a lower and upper stage for which he used the terms Palaeogene and Neogene respectively. This nomenclature is useful, and it is a pity that it has fallen into disuse. Johnston, however, did not appreciate the extent of the Pleistocene deposits in unglaciated areas. I include the whole of Johnston's Neogene in my Pleistocene (Lewis, 1935). Johnston's Palaeogene extends from Miocene to Pliocene, probably including the whole of these periods. It appears to me that Johnston's correlations throughout Tasmania are difficult to sustain and he has not stressed sufficiently the effects of erosion and resorting of these sediments. The basalts (as will be discussed later) are now considered to represent at least two, and probably many, volcanic stages separated by long time intervals. In a word, the Tasmanian Tertiary and Recent rocks represent a more complex sedimentation than Johnston appears to visualize, and the problems presented by these rocks are now seen to be far more complicated than they appeared 50 years ago. I cannot accept Johnston's idea of lakes of very considerable area and depth, although lacustrine basins certainly existed. I visualize these as local in area and limited in time. With these exceptions, I confirm Johnston's remarkable work.

Since Johnston wrote, important descriptions of Tertiary deposits have been recorded by P. B. Nye (1924) in southern Tasmania. I can only confirm his observations, although with the same comments as those in Johnston's correlations (see also remarks by the same writer (1923) on the Waratah Tertiaries, and by

A. M. Reid (1923) on the same area). These accounts, however, do not carry us further than Johnston's more detailed descriptions. Some brief remarks on the Tertiaries of the Ringarooma Valley are also made by Nye (1925).

In this paper, I confine myself to observations on the correlation between the deposition period and the plateau elevations. The most useful key is the basalt, which must be considered with the Tertiary deposits, as both are comparatively contemporaneous and in most places the basalt has largely contributed to the preservation of the older Tertiaries. The materials of the Tertiary conglomerate have not been adequately studied. I have already noted the prevalence of pebbles of quartzite and other Lower Palaeozoic rock types in lower beds of Tertiary conglomerate and the absence of dolerite pebbles. I am in some doubt as to whether I did not place too much reliance on this factor, and my identification has been somewhat shaken by a determination that the 'quartzites' at Millbrook Rise or in the terraces exposed by the excavations at Boyer are very largely of sands metamorphozed by basalt occurring higher up the Derwent, i.e., 'Greybilly' pebbles, and not Lower Palaeozoic from the western country. This does not apply to many of the South Esk valley deposits. There is a possibility that, prior to the plateau uplift, there were considerable accumulations of conglomerate beds consisting of pebbles derived from Western type country subsequently to the elevation of that area, but owing to resorting and the absence of reliable petrological data it is dangerous to build any correlation on this fact yet. It should, however, be borne in mind.

The basalts would present the most useful correlation but, unfortunately, it appears that there have been more than one series of eruptions separated by long time intervals and, to date, agreement has not been reached on the relative age of the more important flows. R. M. Johnston and P. B. Nye also dealt with the basalt in its relation with the Tertiary deposits. More recently, Dr. Austin Edwards (1939) has contributed a comprehensive study of this point. All these writers have recognized the difficulties of correlation, and the accounts clearly show, in consequence, some deduction.

The difficulties in correlation between the Tertiary sediments, the basalts, and the plateaux uplifts may be stated thus—

Basalts range in altitude from 2000 ft. at Waratah and perhaps 2500 ft. at Guildford to sea-level. They traverse the whole north coast from 600 ft. to sea-level and extend at similar elevations through the Midlands, Derwent, Jordan, and Coal River valleys. In all these cases they are to be seen overlying the older Tertiary sediments, some of which are of Miocene age. Along the north coast they frequently overlie Western type country which has been peneplained prior to the eruptions. Elsewhere they occur in valleys eroded in dolerite and Triassic sandstones and which had reached maturity. All these occurrences fit in well with each other, and the evidence of the origin of the physiography derived from all other sources. Then in the middle of the terrain affected by these eruptions there stands the Central Plateau. Here basalts are found from 3500 ft. to 2500 ft. with a widespread distribution down the centre until they are cut off at about 2000-1500 ft. by an obvious post-basaltic uplift. South of this fault zone they are continued in the lower Derwent valley from about 750 ft. contour and thence to sea-level. (The official Geological Survey map does not show these basalts as nearly as extensively as they actually occur.) A further considerable occurrence exists on the lower steps from Lake Sorell southwards, as described by Edwards. Round Hobart we see basalt on Mt. Wellington at 4000 ft. and a line of eroded occurrences resembling a flow down an old river valley now broken by faults and

extending from High Peak at 1400 ft. and Cades Hill (1120 ft.) to below sea-level at Margate and Tinderbox. On both sides of the Clarence Hills there are remnants of much eroded higher-level basalts with visible bases at 200 ft. (Risdon), 100 ft. (Droughty), 450 ft. at Cremorne, 200 ft. (Breakneck Hill), 100 ft. (Cambridge), and 200 ft. (Acton). A similar high-level basalt occurs at Melton (Mt. Vernon), with its base about 100 ft. above the present level of the Jordon valley.

Then there is another suite running down the Jordan valley from Pontville to the Derwent estuary, and a similar occurrence in the Coal valley and at Sorell and also at New Norfolk and Boyer, with the base well below sea-level (over 100 ft. in the few occurrences which provide data).

If these basalts were all of the same age, the problem would be simple. They are certainly post-Lower Miocene, because they overlie beds containing fossils which can reasonably be assigned to a Miocene age. The age of the basalts could be Pliocene on this evidence. They are cut by post-basaltic faulting, and this faulting produced valleys which have been invaded by Pleistocene glaciation. The basalts must therefore be pre-Pleistocene. So far, so good. But it appears certain that the basalts are not all of the same age and that eruptions occurred from Lower Miocene to Lower Pleistocene times. No petrological key to age or relative date of occurrence is forthcoming.

Therefore, instead of being able to use the basalts as an easy key to physiographic history, we have to turn to physiography to give us a solution to the basalt problem.

If the basalts of the Waratah area, the Great Lake area, and the Macquarie-South Esk valleys were contemporaneous, they must have preceded the plateau uplifts or at least the latter half of the stages of that uplift. The same applies to the Mt. Wellington and Derwent basalts. Palaeontological evidence shows that the Midlands valley has existed since Miocene times, and as will be discussed later. It is necessary to put at least some of the elevation at least as far back as Miocene or early Pliocene to provide time for the work that has been accomplished by the rivers. Thus the age of the basalts would be Miocene. This, however, is not conceded by a number of authorities (e.g., Edwards). If the basalts are post-uplift, then there must have been separate occurrences, some confined to the valleys and coasts and some to the centre of the plateaux. This opens up an interesting tectonic problem.

But the immediate sub-basaltic sediments at, e.g., Waratah (1750 ft.) and Geilston Bay (just below sea-level), are the same and of the same age and both are lacustrine deposits which could not have been formed in their present localities. Again the valleys of the Nive (Tarraleah) and Ouse (Waddamana) have cut 1000 ft. below the base of the river down which the basalt flowed. While in the Derwent, and on the north-west coast at many places basalt flowed down river valleys which have since been submerged below sea-level. Therefore, I postulate an uplift of considerable tracts of country in post-basaltic times, and an age for much of the basalt as no younger than the close of the Miocene period. I also postulate depression to at least a few hundred feet in other localities. This necessitates a period of earth movements in Pliocene times.

Using first the basalt eruptions as a datum time, we find the erosion of the Midlands valleys, lower Derwent, Coal, Jordan valleys and the coastal plains in pre-basaltic times. That there are definite erosion valleys and erosion implies something to erode. Therefore, I postulate the 1500 ft. uplift as occurring in pre-basaltic times. This erosion was completed prior to the deposition of Miocene sediments and I therefore place the 1500 ft. uplift as pre-Miocene and sufficiently so to warrant dating it as Oligocene. The most extensive basalt flows, i.e., those

in the Midlands, lower Derwent valley, and along the north coast have been protected from erosion by their location at (relatively) base-level. The Tarraleah-Waddamana-Lake Sorell basalts are definitely cut by the uplift to 2500 ft., and are therefore pre-uplift. It is reasonable to correlate these with the basalts which overlie Miocene sediments, and so we can date this uplift as late Miocene or Pliocene. The north-western basalts occur as a relatively thin sheet overlying Palaeozoic (including Permian) strata exposed by previous uplifts. The basalt is broken in numerous steps from Guildford (2400 ft. to sea-level), and under the basalt lies similar Miocene sediments. We therefore have a 2500 ft. uplift along an axis running east and west through Guildford and Middlesex.

In immediately pre-basalt times (Miocene) there were extensive developments of lacustrine and marine conditions at places now appearing at different levels (Macquarie Harbour, sea-level; Guildford and Waratah, 2400-1750 ft.; Marrawah and Wynyard, sea-level; Longford to Tunbridge, 600-750 ft.; Lower Derwent valley, 100-500 ft.). This development indicates tectonic movements, probably slightly negative, in immediate pre-basaltic times. Subsequently to the eruptions, the sediments and their protective basalts have been elevated as indicated. If this post-basaltic elevation is accepted, the present difference in levels can be thus explained. The Midlands type country seldom shows basalt at over 1000 ft. elevation, and this holds good for the north coast. The basalts cut by the Ouse and Nive rivers stand roughly at the same height as those of Guildford and Waratah, 2500 ft.

We now come to the greatest objection to the above sequence. Dr. A. B. Edwards' opinion that the Central Plateau basalts are later than the age I have afforded to them and may be middle Pleistocene. I admit the strength of Dr. Edwards' arguments, but we have the Marrawah and Bulmers Hill basalts which are placed as pre-Miocene-Oligocene (Nye and Blake, 1938, Edwards, 1939). We have the Tarraleah-Waddamana basalts cut by late Miocene-early Pliocene uplifts. In the Derwent valley and elsewhere there are at least two eruptions separated by long-time intervals, as will be described later. Some of these basalts are considered to be Pleistocene. We have the further difficulty that the basalts do not appear to have been affected by glaciation. This may be due to poverty of observation, but, as far as I can see, the Guildford basalts at 2500 ft. were not glaciated, while ice reached sea-level at Zeehan—twenty miles away. The Great Lake basalts, similarly, do not appear to have been glaciated. The probable explanation is that we have a post-Malanna (Middle-Pleistocene) basalt volcanic phase. This appears certain from evidence around Hobart. To such a phase can be assigned at least the Great Lake and Lake Sorell basalts and many of the coastal occurrences.

Here, I can do no more than stress that basalt, as R. M. Johnston recognized, has been erupted in Tasmania at widely separated intervals over most of the Tertiary period. The basalts described by Dr. Edwards at the Great Lake are probably not referable to the same eruptions as those at Waddamana and Tarraleah. The separation of the different basalt flows on any particular area is a matter warranting detailed study.

These eruptions must have been the result of tectonic influences, and it appears that most, even the most recent, have been slightly broken by faulting, indicating earth movements to some extent during Middle Pleistocene times. These will be discussed later.

It appears, therefore, that we first had a middle Tertiary uplift to 1500 ft. more or less. This may have been the result of the same series of movements that produced the elevation of blocks and subsequent erosion of which gave us Permian strata on the surface. It could equally be a somewhat later phase. In any case, it is noteworthy that the principal areas in which Permian rocks

appear on the surface are near the coasts. These plateau uplifts were, as already stated, always gentle and appear to have been in steps—with 200 ft. as about the average. The pressure was unequally exerted and the result has been that there is a considerable difference in resulting elevation. This is more marked on the Central Plateau.

Summary

In general, there was a period during which Tasmania was squeezed by pressure from the east and south-east against the west or against pressure from the west and south-west. This pressure lasted from Cretaceous to Pleistocene times. The pressures were not continuous, but produced small uplifts which released the pressure, and a considerable time-interval elapsed before the accumulation of stresses again overcoming the natural resistance of the rock masses. Although I have spoken of uplifts to 3000 or 1500 ft., all the evidence points to a gradual uplift in definite and very small stages to this average height. So with the plateau uplifts. The evidence simply becomes more detailed as we approach present time and so the movements appear to be more complicated, but, in fact, there is no evidence of any major disturbances since the dolerite intrusions. At the same time we have to explain the various patterns of areas of rocks of different ages with the collorary that more recent rocks have been elevated and eroded.

Lacustrine deposits were elevated and a little later, as a result of the pressure basalt, was squeezed out in certain areas. The elevation resulted in an older plateau highly eroded into mature valleys. Later the higher plateaux were elevated in even smaller cubes out of areas previously elevated. Basalt eruptions continued and then later elevations cut and separated flows of the earlier basalt.

These movements extended into Pleistocene times, but the effects became gradually less intensive in both area and vertical effect. At the time of the onset of the Ice Age, tentatively assigned to Lower Pleistocene times, we see the plateaux to be much the same physiography as we now know—wide valleys eroded to base level and largely covered by basalt.

References

Edwards, A. B., 1939.—The Age and Physiological Relationships of some Cainozoic Basalts in Central and Eastern Tasmania. *Proc. Roy. Soc. Tas.*, 1938 (1939), pp. 175-199.

Hills, L., 1922.—The Progress of Geological Research in Tasmania since 1902. *Proc. Roy. Soc. Tas.*, 1921 (1922), pp. 111-146.

————, McIntosh-Reid, A., Nye, P. B., Keid, H. G. W., and Reid, W. D.—Coal Resources of Tasmania. *Geol. Surv. Tas.*, 1922.

Johnston, R. M., 1887.—The Nature and Classification of the Tertiary Rocks of Tasmania. *Proc. Roy. Soc. Tas.*, 1887, pp. 135-157.

Lewis, A. N., 1927.—Isostatic Background of Tasmanian Physiography. *Proc. Roy. Soc. Tas.*, 1926 (1927), pp. 1-24.

————, 1928.—Geology of the Catamaran Coalfield. *Proc. Roy. Soc. Tas.*, 1927 (1928), pp. 188-210.

————, 1935.—Pleistocene Raised Beaches and River Terraces in Unglaciated Areas. *Proc. Roy. Soc. Tas.*, 1934 (1935), pp. 75-86.

————, and Voisey, A. H., 1938.—A Record of Volcanic Activity in Tasmania during Triassic Times. *Proc. Roy. Soc. Tas.*, 1937 (1938), pp. 31-39.

————, 1940.—Geology of the Tyenna Valley. *Proc. Roy. Soc. Tas.*, 1939 (1940), pp. 33-59.

Nye, P. B., 1921.—Underground Water Resources of the Midlands. *Geol. Surv. Tas.*, 1921, No. 1, pp. 70-72.

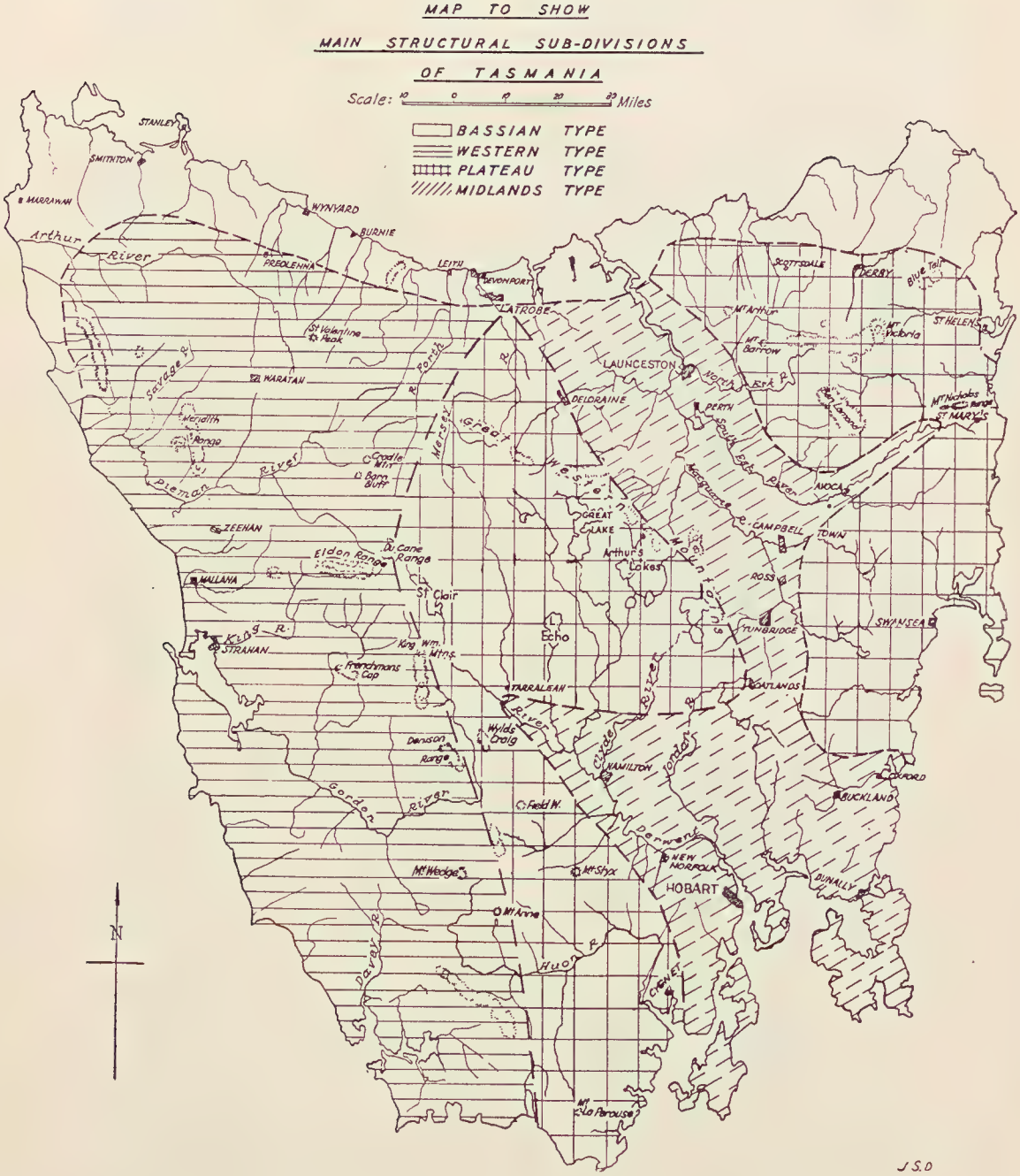
————, 1923.—Silver Lead Deposits of Waratah District. *Geol. Surv. Tas.*, 1923, No. 33, pp. 34-35.

————, 1924.—Water Resources Papers. *Geol. Surv. Tas.*, 1924, No. 3, pp. 24-30.

————, 1925.—Tertiaries of Ringarooma Valley. *Geol. Surv. Tas.*, 1925, No. 35, pp. 15-16.

————, and Blake, F. N., 1938.—Geology and Mineral Deposits of Tasmania. *Geol. Surv. Tas.*, 1938, pp. 21-32.

Reid, A. M., 1923.—Mt. Bischoff Tin Field. *Geol. Surv. Tas.*, 1923, pp. 26-27.


MAP TO SHOW
MAIN STRUCTURAL SUB-DIVISIONS
OF TASMANIA
Scale: 10 0 10 20 30 Miles
BASSIAN TYPE
WESTERN TYPE
PLATEAU TYPE
MIDLANDS TYPE
STANLEY
SMITHTON
MARRAWAH
WYNYARD
BURNIE
Arthur River
PREOLENNA
LEITH
DEVONPORT
LATROBE
St Valentine Peak
WARATAH
Savage R.
Meridith Range
Pieman River
Cradle Mtn
Barn Bluff
Mersey R.
Great Western Mountains
DELORAINE
LAUNCESTON
North Esk R.
PERTH
South Esk River
Macquarie R.
SCOTTSDALE
DERBY
Blue Tail
Mt Arthur
Mt Barrow
Mt Victoria
ST HELENS
Mt Nicholas Range
ST MARY'S
AVOCA
CAMPBELL TOWN
GREAT LAKE
Arthur's Lakes
ROSS
TUNBRIDGE
SWANSEA
OATLANDS
ZEEHAN
Eldon Range
Du Cane Range
MALLAHA
St Clair
King R.
STRAHAN
King Wm. Mtns.
Frenchmans Cap
Echo
TARRALEAH
Wylds Craig
Denison Range
Gordon River
Clyde River
Jordan R.
HAMILTON
COXFORD
BUCKLAND
Field W.
Derwent
NEW NORFOLK
HOBART
DUNALLY
Mt Wedge
Mt Styx
Mt Anne
Huon R.
Davey R.
CYGNET
Mt La Perouse
N
J.S.D

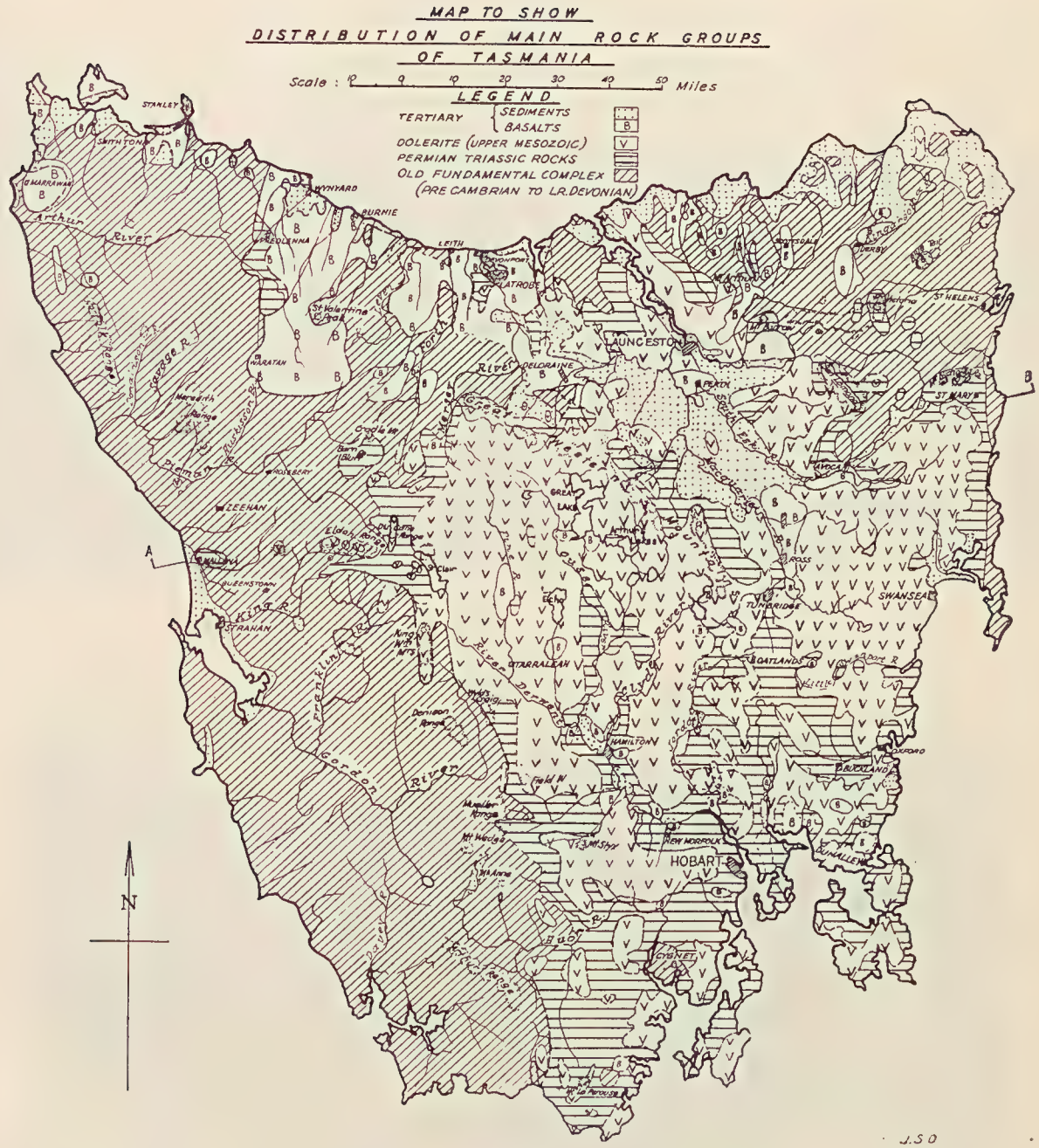

MAP TO SHOW
DISTRIBUTION OF MAIN ROCK GROUPS
OF TASMANIA
Scale : 0 9 10 20 30 40 50 Miles
LEGEND
TERTIARY SEDIMENTS
BASALTS
DOLERITE (UPPER MESOZOIC)
PERMIAN TRIASSIC ROCKS
OLD FUNDAMENTAL COMPLEX
(PRE CAMBRIAN TO LR. DEVONIAN)
STANLEY
SMITHTON
WYNYARD
BURNIE
LEITH
DEVONPORT
LATROBE
ULVERSTONE
LAUNCESTON
DELORAINE
PERTH
ST HELENS
ST MARYS
SWANSEA
TRIABUNNA
ORFORD
BRIDGEPORT
HOBART
NEW NORFOLK
CYGNET
HUON
DUNALLEN
QUAMBY
ZEEHAN
QUEENSTOWN
STRAHAN
ROSEBERY
WARATAH
Arthur River
Pieman River
Savage R.
King R.
Franklin R.
Gordon River
Derwent River
Forth River
Mersey River
Meander River
South Esk River
Macquarie River
Ouse River
Clyde River
Huon River
Davey River
Port R.
Little R.
Great Lake
Arthur Lake
Lake Pedder
Mt Wedge
Mt Anne
Mt Field N
Mt Lyell
Mt Zeehan
Mt Sprent
Mt Black
Mt Victoria
Mt Stuart
Mt Direction
Mt Roland
Mt Barrow
Mt Cameron
Mt Cameron W
Mt Ossa
Mt Pelion W
Mt Pelion E
Mt Oakleigh
Mt Jerusalem
Mt Arrowsmith
Mt Darwin
Mt Sedgwick
Mt Olympus
Mt Gell
Mt Hamilton
Mt Hall
Mt Claude
Mt Ida
Mt Barn
Mt Bischoff
Mt Heemskirk
Mt Murchison
Mt Read
Mt Owen
Mt Dundas
Mt Balfour
Mt Black
Mt Victoria
Mt Stuart
Mt Direction
Mt Roland
Mt Barrow
Mt Cameron
Mt Cameron W
Mt Ossa
Mt Pelion W
Mt Pelion E
Mt Oakleigh
Mt Jerusalem
Mt Arrowsmith
Mt Darwin
Mt Sedgwick
Mt Olympus
Mt Gell
Mt Hamilton
Mt Hall
Mt Claude
Mt Ida
Mt Barn
Mt Bischoff
Mt Heemskirk
Mt Murchison
Mt Read
Mt Owen
Mt Dundas
Mt Balfour
N
A
B
J.S.O

PLATE IV

FIG. 1.—Entrance to Port Davey, Tasmania. Showing steep-sided slopes, and relatively shallow entrance to inlet.

FIG. 2.—Bramble Cove, Port Davey, Tasmania.

(Photos by courtesy of the Tasmanian Tourist Bureau.)

PLATE V

Looking across Bathurst Harbour from height above New Harbour, Port Davey, South Coast of Tasmania. Showing dissected nature of country and typical flat valley floor characteristic of the Button Grass Plains.

(Photo by courtesy of the Tasmanian Tourist Bureau.)

Pap. & Proc. Roy. Soc. Tasmania, 1944 (31st December, 1945)

Pleistocene Glaciation in Tasmania

By

A. N. Lewis

Part I—Tasmania: The Background

1. Geographical

Tasmania is one of the three marginal areas of the Southern Hemisphere which was affected by glaciation during the maximum phases of the Pleistocene Ice Age and which is now uncovered for study. No permanent snow fields now exist anywhere in Australia, but the southern extension now known as Tasmania was heavily glaciated at no distant date, while less extensive glaciation occurred about Mt. Kosciusko (7358 ft.) on the south-east of the Australian mainland.

Tasmania lies between 40-30° and 43-30° south latitude. It is an island by reason of the flooding of the low-lying connexion with Australia, now Bass Strait (maximum depth of 55 fathoms, but an isthmus would be created by rise in strand line of 180 ft.). It has an area of 26,000 square miles, somewhat bigger than Scotland and smaller than Ireland.

As an island, Tasmania escapes the continental conditions of mid-America, but it stands in the full force of the Westerly drift—the 'Roaring Forties'.

Snow at sea-level is rare. It is frequent in winter months at altitudes over 600 ft. and about one-fifth of the island, lying over 3500 ft. is covered with snow for about three months in an average year. Snow may fall on the mountains at any time, and winter drifts usually persist in a few spots till mid-summer. The present-day average temperature is remarkably equable—about 65° F. for summer and 50° F. for winter.

Tasmania is a region of violent contrasts. The higher mountain ranges towards the west often receive over 150 inches of rain a year. This is an area of temperate rain forest with a vegetable growth which defies cultivation and swallows up once prosperous mining towns in a generation. In the sheltered valleys of the centre and east, the rainfall drops to as little as 15 inches a year and arid conditions resembling those of the Australian mainland exist.

2. Topographical

Tasmania is a country of high relief, although not high altitude. Its highest mountain—Legge Tor, on Ben Lomond is only 5160 ft. above sea-level, but there are very few square miles of flat country anywhere. The island is really a highly dissected peneplain, the elevation of which has occurred in mutually separated blocks and in three or four time-phases.

All the western third—practically from the west coast to 147° east longitude—is in the rain-forest belt. This is mostly a sea of forest, equalling in impenetrability any tropical jungle, and largely of vegetation indigenous to the island. Out of this protrude serrated peaks of pink quartzite. At an elevation of 1500 ft. the forest gives place to a sub-alpine flora, in which beautiful flowering shrubs and native pines predominate. The main valleys at their lower levels are wide,

glacial swamps covered by a peculiar sedge 'Button Grass' *(Gymnostachea spharrocephalus)*. The sides of the mountains are seamed with precipitous gorges and their peaks are ringed with mountain tarns of exquisite charm.

Eastward of this still little-known and practically unmapped region rises the rampart of the Central Plateau—a mass of dolerite, weathering to a red-brown colour, some 15,000 square miles in area resting on the older quartzites exposed to the west. The western edge of the plateau is cut by still deeper and wider gorges which enclose near their heads the finest of Tasmania's glacial lakes (Lake St. Clair is ten miles long and over 700 ft. deep). Isolated residuals, sometimes cirque-girt, mark the original extremity of the uplifted area and merge with the somewhat lower pink quartzite peaks of the extreme west. Green forest flows like a sea round them all. Further east again, the deep erosion channels disappear and the plateau surface becomes a stretch of windswept, ice-scraped upland dotted with innumerable pine-girt lakelets to the west, and long, narrow belts of summer pasture to the east. Near the centre are some large lakes, the most impressive being the Great Lake (60 square miles) occupying shallow rock basins. The average altitude of the plateau is 3300 ft., with the southern third about 1000 ft. lower, and with long ridges, particularly at the northern edge, rising to 4500 ft. Then, to the north and east, the plateau drops, by precipitous steps, to broad, mature river valleys of great fertility.

A smaller, but roughly similar plateau occupies the north-eastern sixth of the island. South-west of the Central Plateau are a large number of small plateaux, separated from the main uplifted area by broad still-stand areas largely modified by subsequent erosion, and stretching to the south coast. The south-eastern sixth of the island consists of a lower plateau averaging 1500 ft. in altitude and now dissected into a confusing jumble of rocky bush-covered hills and narrow valleys, sometimes stony gorges, sometimes fertile farm lands.

There has been much loss of territory by comparatively recent sinking. The east and west coasts are marked by jagged fault lines, and towards the south are often fringed by high cliffs. The south coast is a maze of deep indentations—the drowned heads of former valleys. The north coast is made by the flooding of Bass Strait and the drowning of the older waterways.

All the coast lands, except to the south-west and the lower reaches of the main rivers, are extremely fertile, carrying an agricultural population well above the average for Tasmania, and the source of much of Australia's supply of apples, hops, small berry fruits, oats and potatoes, butter and mutton. In general, most of the lower, long, flat coast lands and valleys closely resemble the richest parts of England, but most of the island is wider and more angular than the highlands of Scotland, plus a mantle of cold, wet jungle.

In addition to other advantages for the student, we may add that of accessibility. Hobart, the capital of the State, can be reached from Melbourne in three hours by daily air service and in twenty-four hours by ferry steamer and train. Queenstown, the site of the Mt. Lyell copper mine, is a prosperous centre right in the midst of the most heavily glaciated region and is only 100 miles by first-class road from Hobart, and Strahan, its port, on the west coast is only twenty-five miles further on. Tracks open up most of the best mountain resorts.

3. Geological

It is practically impossible to pass in a straight line for a mile anywhere in Tasmania without crossing a change of rock, and almost every geological epoch is represented to an extent that there can be few regions of similar area which can present so much of interest. This, however, has little bearing on glaciology.

TASMANIA
SCALE OF MILES
5 0 5 10 15 20 25 30
RAILWAYS
Map Showing Area of Maximum Glaciation
Flinders Island
Cape Barren Island
Clarke Island
BANKS' STRAIT
Hunter Islands
Robbins Island
Stanley
Rocky Cape
Table Cape
Wynyard
Burnie
Devonport
Beaconsfield
Latrobe
Leroy
Cape Portland
Gladstone
Pioneer
Derby
Lottah
Branxholm
Lisle
Launceston
Mathinna
St. Marys
Seymour
Avoca
Marrawah
Arthur River
Ballour
Sandy Cape
Wiratah
Magnet
Tullah
Rosebery
Williamsford
Zeehan
Dundas
Lake Margaret
Queenstown
Yolande R.
Mallens
Cape Sorell
Macquarie Harbour
Point Hibbs
Lake St. Clair
Lake Echo
Lake Sorell
Lake Crescent
Swansea
Oyster Bay
Freycinet's Peninsula
Schouten Island
Spring Bay
Maria Island
Hobart
Margate
Storm Bay
Tasman's Peninsula
Cape Pillar
Cape Raoul
Bruni Island
Port Davey
S.W. Cape
Cox Bight
Recherche Bay
S.E. Cape
Glaciated
Doubtful Extensions (Fluvio-glacial)

To avoid possible confusion in a reading of geological literature, it may be mentioned that Tasmanian mining fields are in the western and north-eastern areas, mostly in close association with glacial features, but this is quite a fortuitous coincidence arising from two separate factors.

The basal rocks are in part pre-Cambrian schists, followed by more widespread suites of Lower Palaeozoic strata of all types, highly crystallized by severe orogenic movements, accompanied by intrusions of granite and other plutonic rocks during late Silurian to early Carboniferous times. A major chain of folded mountains then formed was eroded to a peneplain, on which was deposited marine sediments of later Permian age and freshwater sandstones with coal measures extending into Mid-Triassic times. Then occurred the intrusion of sills of dolerite over most of Tasmania. These are often 2000 ft. thick and impart a distinctive character to all Tasmanian landscapes.

Another peneplaination was complete by Miocene times, and this was broken by a long-continued series of vertical uplifts. In the parts earlier affected erosion has exposed the Lower Palaeozoic rocks.

Long, narrow stretches of country were unaffected, and in these is to be found a suite of Pliocene-Pleistocene fluviatile deposits interstratified with extensive flows of basalt lavas which cover much of the country. The history of the Late Tertiary and Pleistocene periods has been unravelled from the data supplied by these deposits and basalts in relation to the topographic features and the superimposed glaciations.

4. Glaciology

Tasmania shows, to-day, a topography which in the south-western sixth of the island and throughout the western third over an altitude of about 2300 ft. has been in the main moulded by ice action. In the more favoured localities, three distinct ice invasions are clearly visible and the middle one of these can be divided into two phases. The southern, eastern and northern coast lines show very distinct evidence of three periods of higher sea-level and four of lower sea-level during the Pleistocene period.

The existence of Pleistocene glaciation has been recognized since 1849, and since the account published by R. M. Johnston in his Geology of Tasmania (1888) many descriptions have appeared. Most of the glaciological literature is to be found in the Papers and Proceedings of the Royal Society of Tasmania, with frequent incidental references in the Bulletins of the Geological Survey of Tasmania and the reports of the Glacial Committee in the Proceedings of the Australasian (now Australia and New Zealand) Association for the Advancement of Science.

Part II—Glacial Features and Associated Events

The absence of marine (and, for long intervals, even terrestrial) sediments due to the fact that, from the time of the dolerite intrusions (Jurassic or Cretaceous) to Pliocene times, Tasmania was a land surface, throws us back on erosion features as the only guide to chronology.[1] It appears clear that the mountain, plateau, and valley system was much as we now see it when the Pleistocene glacial period commenced. Prior to this, uplifts had occurred to give the main and more highly elevated features, but the movements did not conclude until well into the Pleistocene period.

[1] Marine transgression in southern Victoria in latest Oligocene-early Miocene times, extended to the northern coast of Tasmania in one area at least and gave us marine sandstones at Wynyard. These are rich in shell fossils, and have been correlated with the Janjukian-Miocene beds of Victoria.

Three subsequent events have proved to be of the highest importance in correlation of the glacial features with river terraces, &c., in unglaciated areas. These are—

(1) The deposition of distinct and widespread terrestrial series of sediments in the valleys formed as the result of the Mid-Miocene differential plateau uplifts.
(2) The covering of these deposits in places by flows of basaltic lavas which followed in the main the then existing valleys.
(3) Disruption of the basalt flows by continuance of the uplifts and the consequent erosion of new valleys and isolation of residual hills of river gravels protected by caps of resistant basalt.

The whole of this series of rocks and events has been termed by the present writer the *Launceston Stage*. Its importance lies in the fact that a second suite of gravels and basalts exists which is referable to a low-water phase during the Ice Age, and between the two occurred the first glacial phase. The glacial chronology has been worked out by a correlation of glacial features with two basaltic volcanic phases.

The Launceston Stage is distinctive—limestones, sandstones, and clays. Often very hard rocks are found beneath more recent river deposits in a number of places, both in the north and in the south of the island. The division of the Launceston Stage into two sub-stages is based on the occurrence, near Hobart, of two groups of beds referred to the Launceston Stage. The lowest beds which the present writer terms the Geilston Sub-stage contains a rich *Nothofagus* flora. Above this occur beds with a rich *Eucalyptus* flora, to which the name *Sandy Bay Sub-stage* has been assigned. Both of these occur near Hobart. The two may be relatively continuous. The small masses of these sediments preserved are almost always protected by overlying basalt, and show evidence of deposition at river valley level. There has been much elevation of the land since these Launceston Stage beds were deposited, but it is clear that at the time of their deposition sea-level was lower than it is to-day, because in some localties (for example, Penna, on the Tamar River) they extend below present sea-level, and yet they are clearly terrestrial deposits without a trace of marine organisms.

The volcanic phase which followed immediately cannot be dissociated from the uplifting movements. The more usual products were long, shallow lava streams which flowed down the existing valleys. Towards the north-west, some of these formed wide sheets of igenous rock. Near Waratah (Mt. Bischoff), lava flows overlying leaf beds of this stage stand at 700 ft. above sea-level. At the Great Lake basalt-filled valleys with some sub-basaltic river gravels still exist at an elevation of 3400 ft. It is not possible as yet to correlate these higher plateau basalts with the uplifts, but the present writer considers that, at least in the higher localities, the volcanic phase followed the commencement of the uplifts. Elsewhere, these older or higher basalts, which may be termed the Cremorne basalts (a name adopted by the present writer to distinguish the occurrence round Hobart) have been clearly broken by subsequent elevation and a 350-450 ft. uplift since the volcanic phase is in evidence almost everywhere. After the uplift, the older rivers were rejuvenated and eroded valleys in their previous deposits, cutting out the soft rock and leaving lines of hills or ridges where the basalt gave protection.

Towards the north-west (Waratah) area, the surface of the basalt is glaciated. The edge of the 2500 ft. plateau on which it lies is deeply eroded by river systems which show no sign of glaciation in their precipitous headwater sections, but contain glacial deposits at their lower levels. From this may be deduced that, since

the glaciation of this area, river rejuvenation has occurred. Such an uplift—350 ft. appears to be the average of actual movement—is noticeable throughout Tasmania. It breaks across sedimentary rocks of the Launceston Stage at Evandale, has produced deep gorges on the north-west and east coasts, and is traceable through southern Tasmania. The famous Cataract Gorge in the City of Launceston is a result.

Professor David assigned the origin of many features on the west coast to a post-glacial isostatic recovery. Continuing observations from glaciated to non-glaciated areas, the present writer has traced the same elevation throughout Tasmania with little differentation assignable to post-glacial recovery. The glaciated areas at the maximum did not include one-third of the total area of the island. For this reason, some other cause must be sought. However, just here the uplift experienced by the whole of Tasmania is important as a correlating factor.

Tasmania has lost very considerable areas of land round all its coast-line by submergence. All the data at present available points to a date for this submergence roughly contemporaneous with this uplift just mentioned. This, again, is an important fact. The formation of Bass Strait cannot, in the writer's opinion, be assigned entirely to post-glacial flooding, because terraces attributable to high-water phases are found round its shores exactly as round the shores of other coasts. Post-glacial flooding obviously had a great effect on the location of the sea-shore and, perhaps, created a strait, but it is not sufficient to explain the formation of the lowlands in such sharp contrast with the neighbouring coastal peneplain which stands 350-450 ft. above sea-level right to the coast. Similar features are found down the east coast and round the south coast, modified in places because the uplift affected wide mature river valleys separated by hilly divides.

Malanna Glaciation

The first glacial phase occurred after the effusion of the older basalts. The present writer has termed it the Malanna glaciation after the location on the west coast where it was first identified as a separate phase by Loftus Hills (1914) and Sir Edgeworth David (1924). This glaciation was more extensive than the succeeding ones, although its remains are not so impressive as those left by the Yolande phase.

The Malanna glaciation is deducible from traces of moraines at a lower level than those of the second or Yolande glaciation and from definitely glacial valleys with rings of Yolande moraines extending round their upper reaches. It is difficult in many places to distinguish from the later glacial phase as the Yolande glaciers occupied and remodelled the cirques and valleys of the older glaciation. Although, in some instances, the courses of the two sets of glaciers were equally extensive, in most valleys the Malanna glaciers were much more extensive and sufficient evidence exists to fix the average extension of the Yolande glaciers down the Malanna glacial valleys.

The most useful key to the separation of the two phases is river erosion due to rejuvenation following the most recent uplift.

In general terms, ice reached the sea during Malannan times over most of south-western Tasmania—from Arthur Heads round to Recherche Bay. This ice came from the highlands to the eastward. Moraines and evidence of glacial erosion abound at sea-level in many places, but inland, the river valleys are for long stretches typical waterworn gorges. Higher again glacial features recur. Frequently low inter-valley divides are covered with morainal deposits and the valleys themselves, where ice flows would be expected, show no sign of glaciation. These

water-cut gorges between the glacial features follow a defined line and occur 350-1200 ft. above sea-level. The evidence makes it clear that a rejuvenation by an uplift of about 350-450 ft. occurred subsequently to the Malanna glaciation. The eroded surfaces and deposits of the later Yolande glaciation are never cut in this way, and the tracks of these glaciers can be traced from cirque head to terminal moraine. This bare statement hardly conveys the full picture. The features resulting from water erosion are so clearly marked, consistent, and varied that there can be no escape from the conclusion that moraines now found at and near the west coast are the products of a glaciation earlier than the final development of the present topography.

In some localities near the edge of the higher plateaux, the Malanna glaciers filled valleys with ice 950 ft. thick, whose floor extended to 800 ft. above sea-level, while the Yolande glaciers have left a completely separate series of features on the mountain tops and did not descend below 2200 ft. The 'remains' of the Yolande glaciation are as clear and fresh as the day when the ice melted and are usually relatively free from vegetation. The Malanna glaciation is tattered with river erosion and can only be traced in scattered fragments. Very often the more impressive glaciated valleys are covered with deep soil supporting dense rain forest. For this reason, it is not possible always to see the topographical features, and their glacial characteristics can only be distinguished when a wide panorama is viewed from a mountain peak. This resulted in a long delay in observing this earlier glaciation—particularly when the neighbouring cirques and lakes of the Yolande glaciation were so distinct.

The most impressive feature of the Malanna glaciation is Port Davey, a glacial fiord, the only one in the Australian region—not in the same category as the fiords of Norway or New Zealand, but, nevertheless, a true example, with white cliffs rising to sharp tinds some 3200 ft. above the deep sinuous channels.

References to other localities in which glacial features assignable to this phase occur may be found in the writers 'Note on Pleistocene Glaciation Mt. Field to Mt. Strahan' and (with J. F. N. Murray) 'Glacial Features in the D'Entrecasteaux Valley'.

Malanna Low-water Phase

Great difficulty has been experienced in exactly fixing the relative position of the terraces representing the high-water phases and the troughs representing the low-water phases. The Launceston Stage is definitely pre-glacial and so are the associated high-level basalts. A trough reasonably correlated with the Malanna glaciation has been identified in the River Derwent and a later volcanic phase with an overlying terrace is also established beyond question, but the present writer has some doubt whether this lastmentioned terrace represents a high-water phase immediately preceding the Malanna glaciation or immediately following it. This difficulty is occasioned by the lack of data relating to the depth of later silts filling the Malanna troughs and the depth of the associated basalts below present sea-level. However, the basalts in places flowed down a trough below present sea-level in a way which would be impossible to-day, and the next deposits lie on top of them. There is no evidence at all of a pre-Malanna low-water phase. Unfortunately, Tasmania cannot be regarded as a stable land surface until Yolande times, but the balance of probabilities on present data are as here stated.

The Malanna glaciation was accompanied by a low-water phase remarkably approximating the similar feature in England. It is suspected in many places, but definitely proved in the estuary of the River Derwent, where a series of bores were sunk in the search for a rock foundation for a bridge. Diagrams are included

in the writer's paper in Papers and Proceedings of the Royal Society of Tasmania, 1934 (1935), p. 80. Remarkable confirmation was obtained in 1938-39 when a bridge company erecting a bridge some two miles south of the locality of section B reproduced as above, acting in spite of the writer's published data struck the shoulder of the Malanna trough in the outer edge of an important abutment and were put to unexpected expense. The Malanna trough winds through the present estuary 150 ft. below present sea-level, tracing the course of the river during a period of low water. This trough is now nearly filled with river silt. It could not possibly have been eroded in this very hard dolerite and mudstone unless the strand line had been somewhat over 150 ft. lower than it is to-day.

Bridgewater Basalts

Somewhere towards the end of the low-water phase there was another volcanic phase. The river channels had been eroded and in a few places basalt lavas flowed down them. The lowest level reached by this basalt has not been ascertained. At Bridgewater it is 60 ft. below present sea-level. At Boyer, some five miles further up the Derwent, it has been bored to the same depth without finding the actual floor.

The Launceston Stage must have been deposited. Then river erosion cut for at least 400 ft. through the older river valleys partly filled by Cremorne basalts. As suggested, this was probably the result of some measure of uplift. Then occurred the low-water phase of the Malanna glaciation and the rivers cut channels another 150 ft. into solid rock—probably 100 ft. below the floor of the Launceston Stage deposits. After this, the second volcanic phase filled some of these troughs with basalt.

Millbrook Rise Stage[1]

The Malanna glaciation was followed by a high-water phase. River terraces were developed—or more probably river valleys were filled with sediments which subsequent erosion has left as terraces. The most typical feature is accumulation of very characteristic river gravels on top of the Bridgewater lower basalts.

These gravels extend on an average to about 150 ft. above sea-level.

There can be no doubt of the sequence low water phase-basalt-high water phase. The gravels on the basalt can be correlated with many other terraces round the coasts. They are particularly well developed at Bridgewater and Huonville.

These gravels are characterized in many places by predominant pebbles of Lower Palaeozoic quartzites, &c. This is significant, as the more recent terraces are predominantly of dolerite pebbles. There can be no question that in places the basalt flows caused lakes and otherwise interfered with the drainage, but wide valleys only partly filled with lava appeared to have been covered by water during the high-water phase to a width many times more extensive than the lava flows.

Yolande Glacial Phase

This glaciation is one of the most spectacular features of the western topography. Every mountain over 3600 ft. high and all the western third of Tasmania over 2200 ft. is heavily glaciated. The mountains and plateau residuals are seamed with cirques, the extremities of which often meet in comb ridges. Lakes occupy some portion of the majority, and typical U-shaped valleys stretch out towards the coastal plains. These are crossed at intervals by moraines. Briefly, every feature of mountain glaciation is to be found.

[1] Millbrook Rise is situated about one mile on the Hobart side of New Norfolk.

The Yolande glaciation was so recent that its characteristics have not been materially altered by erosion. The still more recent glaciation has not affected it. The present writer, speaking in very general terms, would say that the Malanna glaciation ended four times as long ago as the Yolande. The Yolande glaciation does not seem to have been as extensive as the Malanna, but towards the heads of the valleys its glaciers occupied the same cirques and, more or less, filled the same valley troughs. It thus largely obliterated the traces of the earlier glaciation which shows out from beneath the moraines of the Yolande phase only in a few favoured localities. The terrain of the Malanna glaciers has been weathered and new soil grows normal forests. In most places the track of the Yolande glaciers are as the ice left the countryside, largely devoid of soil and with swampy accumulations of clay in the undrained valleys. When in the winter snow covers the landscape, the track of the ancient glacier stands out with lifelike clarity.

The Yolande glaciation was not as extensive as the earlier phase. Often terminal moraines have been left half-way down the cirque sides. In other places, newer glacial valleys have been eroded within or on one side of the older one. The terminal limits of both are very confused and have not yet been satisfactorily differentiated in most places. This is due to the very narrow coastal belt invaded by both glaciations. In most places, terminal moraines of the Yolande phase obliterates observations of the Malanna phase.

The characteristic feature of the Yolande glaciation in the higher altitude is a paired arrangement of mountain lakes.[1] Almost everywhere the lakes, the majority of which are referable to the Yolande glaciation are arranged in pairs. There is usually 300 ft. difference in elevation between the higher and the lower, Sometimes one lake stands above the other up the valley, the longer axis of both and of the glacial valley in which they lie being in the same line, in other cases the lower lake occupies the bottom of the valley and the higher lake or lakes stand on the side empounded by a moraine marking the termination of a glacier which did not reach the valley floor. Sometimes, in complex cirques, there is a main lake at the lower level with a bouquet of smaller lakes occupying the ramifications of the cirque.[2]

From the remarkable regularity as to elevation of these pairs of lakes and the configuration of the valleys which all indicate an old, simple glacial valley further eroded by numerous glaciers which melted before reaching the older valley floor, the present writer concludes that the Yolande glaciation appeared in two distinct phases separated by an interglacial interval. The whole Yolande glaciation probably did not occupy a time interval anywhere approaching that of the Malanna. The present writer places the time interval from the onset of the earlier of the Yolande phase to the present day as less than the Malanna-Yolande interglacial period.

Yolande Low-water Phase

Associated with the Yolande glacial phase was a period of low sea-level. Basalts invaded the Malanna trough which had been filled with river sediments to a height of perhaps 150 ft. above present sea-level. Then came a new low-level phase, during which the Malanna-Yolande interglacial deposits were cut out. Where basalt had filled the valleys, the rivers sometimes excavated new channels alongside,

(1) Lakes Belton and Belcher, and Lakes Nicholls and Rayner in the National Park, and the Arthur Lakes in the midland area are examples.

(2) See sketch plan of Great Lake area, Pap. & Proc. Roy. Soc. Tas., 1932, 'Note on Origin of Great Lake and Other Lakes'; also sketch plan of Broad River valley, Pap. & Proc. Roy. Soc. Tas., 1921, 'Glacial Remains in the National Park'.

but more often swung from side to side, mostly in the older river deposits, but also cutting the basalt flows which now stand in narrow strips first on one side then on the other of the present valleys.

This newer trough was cut to approximately 60-80 ft. below present sea-level in a way, particularly where the frozen valley has been cut, which could not be done by the present rivers. Through the flooded estuaries, this old river channel winds. Its association with the basalt is very marked. Not only do the troughs in the main valleys show the lowering of the rivers, but this is a feature of all the small rivers and dry valleys near sea-level right round the coasts.

Ralph's Bay Stage

After the Yolande glacial stage with its accompanying low-water phase, there was a recovery of strand line resulting in raised beaches, which are to be seen all round the coast. The most outstanding examples are to be found round the shores of Ralph's Bay, south-east of Hobart. About this locality Darwin wrote: 'On the shore of Ralph Bay (opening into Storm Bay), I observed a continuous beach about 15 ft. above high-water mark clothed with vegetation, and by digging into it, pebbles encrusted with serpulae were found . . . ' (Geol. Observations, 2nd edition, 1876, p. 158.)

The only comment that can be made to this is that if Darwin had had longer in Tasmania he would not have confined his remarks to Ralph's Bay. The same features are to be found everywhere. Shore platforms run along the base of every cliff. This is so much a universal feature that, as a boy, I had never pictured the possibility of not being able to walk along the shore-line (the tide in southern Tasmania has only a rise and fall of 4 ft.) and these platforms are rarely submerged for far at high tide. They extend impartially in cliff faces, exposed to the heaviest seas, and these high in estuaries where waves never occur.

The raised beaches consist of compact, but unconsolidated, shell banks interlayered with sand. Sometimes they extend for half a mile from the present seashore and make very rich flats for growing vegetables, melons, and oats. They are extended inland as river terraces. In exposed beaches they are overlain by modern sand-dunes, and the two stages are clearly distinct. Beneath the Ralph's Bay stage lie tough ferrugineous clays at the bottom of the Cambridge or Millbrook Rise stage, and in some sections the three stages are clearly separable. The Ralph's Bay stage raised beaches are often 30 ft. thick, but exposures are not sufficiently frequent to determine the maximum, thickness.

Inland river terraces are to be found almost universally at about 15 ft. above the present river level. These are remarkably fertile and grow Australia's hop crops. This feature is too common to pass notice.

Margaret Glacial Phase

Subsequently to the Yolande glaciation there occurred a third (or fourth) glaciation. This was never as extensive as either the Yolande phases and only affected the tops of the mountains—the lowest levels are in general terms 3700 ft. in the centre and 2200 ft. on the west. All mountains of this altitude were affected, but the Margaret glaciers were small and seldom extended far from their cirque head. The largest observed by the present writer is in the type locality—Lake Margaret, where the glacier was about seven miles in length. Glaciers over one mile in length must have been rare. The most usual feature is rings or groups of small cirque high in the mountains, usually clustered round the top of the Yolande cirques (the conditions for ice production being similar during both phases).

These cirques are frequently occupied by tiny lakes of great beauty. They stand, on the average. 900-1200 ft. above the floor of the Yolande cirques. The walls of the Margaret cirques seldom stand more than 300 ft. high.

Small moraines are common. These are usually distinguishable as traversing country well above the névé and cirques of the Yolande glaciation.

Where accessible, the Margaret glaciation provides excellent examples of ice action, but, in general, they are high above all present roads and are difficult of access. In the type locality, Lake Margaret is a rock basin which forms an excellent reservoir. It is the site of an important power scheme. The original polished ice-scratched rock barrier has been raised by a concrete dam. Water from this is carried a short distance and dropped over the cirque wall of the Yolande glaciation into the Yolande valley. Elsewhere, many similar small hanging valleys attributable to the Margaret glaciation send their water cascading over the cliffs of the Yolande cirques.

It may be asked whether the Margaret phase was not a retreat feature of the Yolande glaciation. The only substantial evidence for two distinct glaciations is *(a)* the universality of the Margaret glaciation at its levels which connects Margaret cirques and tarns wherever they occur; *(b)* the degree of river erosion seen in a few localities between the deposition of the Yolande moraines and the Margaret moraines; *(c)* although in most cases evidence of Margaret glaciation is to be found in the upper levels of Yolande glacial valleys, it is not always so, and Margaret glaciers grew in places covered by Yolande névé. None of these arguments is conclusive. The present writer considers that the general appearance of freshness of deposits, etc., gives the impression that the Margaret glaciers existed at a period far closer to the present day than the time interval between the Yolande ice and the Margaret ice.

Margaret Low-water Phase

After the formation of the raised beaches and associated features a further low-water phase can be traced. Everywhere near sea-level the streams and rivers have cut a channel some 15-21 ft. below present sea-level, exposing sections of the Ralph's Bay stage terraces. This is almost universal. The evidence that this was made possible by lower sea-level and not by normal or flood erosion is shown by the fact that these small troughs and ditches have been flooded by subsequent rise in sea-level and a post-Margaret deposition is in rapid progress within the erosion features referable to this stage.

Part III—Glacial Studies in Tasmania

One of the most outstanding observations for a Tasmanian when reading accounts of glaciation in the northern hemisphere is the remarkable parallel between the features of glaciated landscapes here and those described in published accounts. Taking into consideration the very limited areas of flat land, the relatively small area of glaciation and the sharp relief, there seems to be no described glacial feature which cannot be found reproduced on some scale in Tasmania.

Take, for example, Hobbs' *Characteristics of Existing Glaciers:* Professor Hobbs' chapter on the ' Cirque and its Recession ' is exactly confirmed in Tasmania. The present writer has developed the ideas set out in this paper from observations of cirques. Moraines are a dangerous framework, too liable to deformation by subsequent erosion and to being obscured by forest. Summer snow banks abound. (See Notes on La Perouse Range, Pap. & Proc. Roy. Soc. Tas., 1924 (1925), p. 38,

for a description of a feature that is very common on all mountains.) The illustrations in Professor Hobbs' Plate II could have been taken in Tasmania, although, in general, this dolerite talus is broken in much larger blocks. These summer snow banks are the relicts of the Margaret glaciation, and are usually found near the upper edges of Margaret cirques which are always small and immature. See a typical example illustrated in Pap. & Proc. Roy. Soc. Tas., 1924 (1925), pl. VI, p. 18, fig. 2, and pl. V, fig. 1. These are trivial features compared with the main Yolande cirques, of which the Margaret cirques often form the upper branches. See examples illustrated in Pap. & Proc. Roy. Soc. Tas.. 1924 (1925), pl. IV and pl. VIII, and Pap. and Proc. Roy. Soc. Tas., 1921 (1922), pls XIII and XIV.

The quotation from Johnston quoted in Professor Hobbs' Ch. II on *High Level Sculpturing of the Upland* exactly describes the topography of many Tasmanian plateaux, although, in the majority, the process has extended to the removal of all or most of the pre-glacial surface with only high knife-edge divides remaining. Professor Hobbs' fig. 9 represents the average Tasmanian glaciated upland exactly. Fig. 10 could be a sketch, and fig. 12 a map, of several mountains in Tasmania.

In reference to Professor Hobbs' classification of the stages in the glacial dissection of an upland, pictures in his Ch. II and elaborated in his paper in Journ. of Geol., Vol. XXIX, No. 4, 1921, Tasmania echoes his views. Grooved uplands are very abundant, but the second stage, Early Fretted Uplands, are the most common topography. Horns with main and lateral comb ridges occur in the case of the higher mountains—see illustrations in Pap. & Proc. Roy. Soc. Tas., 1923 (1924), pls II, V, and VI, and 1924, pls III, VI, and VII. In some cases, rudimentary monuments have commenced to appear. See Pap. & Proc. Roy. Soc. Tas., 1924 (1925), pls VI and VIII. The present writer's observations are that glacial horns and monuments commence to make their appearance early in the Hobbs' second stage of Early Fretted Upland, and monuments are well developed by the time the glacial erosion is commencing the stage of Fretted Upland of maturity, In Tasmania, erosion has in no case reached Hobbs' third stage of full maturity, but in some of the more highly glaciated regions it was reaching that stage. It is relatively rare for glaciers to develop equally all round an upland plateau. The usual position is that one edge is highly dissected, with monuments appearing, high cols and occasional glacial horns, but the bulk of the plateau is only slightly affected.

At page 35 (1922 edition), Professer Hobbs says 'Deep glacier cut valleys available as highways and transecting high ranges are extremely rare'. This is the case in Tasmania, and explains much of the difficulty occasioned in opening up the glaciated western country.

Turning to Professor Hobbs' Ch. III 'Classification of Mountain Glaciers': Those of the Nivation type were extremely common in Tasmania. These are referable to the Margaret glaciation.

Ice Cap type have developed on the flat surface of the Central Plateau and were responsible for the Great Lake (see Lewis, 1932). The Piedmont type was represented in the south and west where short glaciers debouched on coastal plains (see Lewis and Murray, 1934). The glacier of the Yolande-Henty-Malanna type locality was also of this class.

Glaciers of the Dendritic or Valley types were by far the most numerous. It is difficult to distinguish which of the Tasmanian glaciers might be referred to the Inherited Basin or Radiating types rather than to the Dendritic type. Some may have occurred in places where their development was particularly favoured by pre-glacial topography, but the writer prefers to regard all such glaciers as local variations of the Valley type.

Glaciers of the Horseshoe type were very common. They occurred on all mountains and were the most usual feature of the Margaret glaciation. Professor Hobbs' Plate XIVA could illustrate many a Tasmanian mountain with winter snow. Plate XIVB resembles Linda Valley closely, although there is no ice now at Linda.

In his Ch. IV Professor Hobbs describes what he calls 'The Cascade Stairways and U Valleys'. Every word in these sections could have been written of the larger Yolande glacial valleys of western Tasmania. Rock bars are very common, and a great addition to the picturesqueness of the scenery. His Plate XVI could be exactly reproduced over thousands of square miles in Tasmania, and fig. 28 might represent a typical Tasmanian mountain top. The form shown in his fig. 30 is also common here. The W-pattern formed by glacial shearing on the side of the main valley of pre-glacial water-worn tributaries is a very distinctive feature.

Tasmania was not affected by a typical ice cap, but much of the level Central Plateau and the highly glaciated area round Port Davey shows local features as illustrated by Professor Hobbs in his chapter dealing with ice caps. His Plate XVIIB is reminiscent of the entrance to Port Davey, and his Plate XVIIIB is reproduced in minature in several places on the south-west coast of Tasmania.

Moraines cover much of western Tasmania, and the present writer finds Professor Hobbs' Ch. VI also exactly applicable. In most cases, the ultimate terminal moraines are now submerged and the lowest moraines of later glaciation have been removed by subsequent erosions, but in many valleys moraines stand out like railway embankments. The moraine at Lake St. Clair is some six miles long and 750 ft. in vertical thickness. Many impounded lakes occur. Professor Hobbs' fig. 44 is almost an exact reproduction of one of the most typical features in Tasmanian scenery. The Strahan terraces as described by David are 'Outwash Aprons' (Hobbs, p. 87) and similar features extend south to Cox Bight. Rock flows occur in all dolerite capped mountains. These have acquired the local name of 'Ploughed Fields'. A good example crosses the road to Mt. Wellington not ten miles from Hobart (see also Pap. & Proc. Roy. Soc. Tas., 1923 (1924), pl. VI, fig. 7), and other references in my papers.

As has been stated, there are no comparisons in Tasmania with the continental ice sheets of higher latitudes, and the rest of Professor Hobbs book is unapplicable.

Turning now to a different problem—that of rise and fall of land and sea during the Pleistocene, we may take Daly's 'Changing World of the Ice Age', 1934—as a useful guide. Tasmania can provide little to advance knowledge of the rise and fall of land in the Pleistocene, except that change of strand line did occur. In the opinion of the present writer, the amount of ice at the maximum would be unlikely to amount to 4000 square miles (half island affected and only one-third of that area actually covered by ice). The maximum thickness I have ever observed would not be over 2200 ft. This would never have been true over the whole glaciated area, and probably 300 ft. would be a fair average over the whole 4000 square miles. This gives only a volume of 250 cubic miles. Even doubling this figure the weight of added ice would be trivial compared with the weight of the land—about 10,000 cubic miles.

There is no doubt that there was an Malanna-Yolande interglacial rise of land surface, but this affected all Tasmania more or less equally—whereas only one-third to one-half was covered by ice. This rise was greater (450 ft.) than the average thickness of ice. It was accompanied by considerable foundering of land round the coast—particularly in the south and probably in Bass Strait. The present writer therefore considers that these earth movements were not the result of accumulations of ice, at least over Tasmania or neighbouring waters.

Tasmania can provide no direct evidence *proving* that glacial epochs were contemporaneous in both hemispheres. There is, however, a remarkable parallel. This is particularly noticeable between the river terraces in the lower reaches of the Derwent and Huon Rivers which entered the sea some 40-60 miles from the nearest tributary glaciers and the River Thames in England, the lowest reaches of which were approximately similarly distant from the edge of the English ice sheet. Further, the evidence tends to the assumption that river terraces representing high sea-level alternated with the Tasmanian glaciations. If the hemispheres had had alternate ice invasions the effect of freezing in one hemisphere and melting in the other would have tended to cancel each other out or there would have had to be twice the development in one hemisphere (northern) than there was in the southern to account for development of river terraces in the southern.

Daly, fig. 22, the present writer would render this diagram for Tasmania as—

Figs 39A and B of Professor Daly's book are of great interest to a Tasmanian reader. Arch Island in D'Entrecasteaux Channel and Spectacle Island in Frederick Henry Bay provide elevated sea cut tunnels exactly similar to those shown in the plates, except that the Tasmanian examples are not as high above sea-level as that shown at Torghatten Island (15 ft. in Tasmania). The marine terrace occurs similarly. Fig. 39B is exactly like a photo of Remarkable Cave near Port Arthur. Figs 80 and 81, particularly the latter, could have been taken in many places round the east coast.

There is at present no sure basis for comparing the Tasmanian glaciations with the great ice sheets of Fennoscandia and North America, although many points in Professor Daly's books can be observed in miniature. Taking his formula and tables in his chapter on Earth's deformation and recoil, the amount of ice in Tasmania was so much smaller than the smallest example given by Professor Daly that the present writer considers it would be dangerous to attempt to extend these calculations to such small occurrences, and the field data in Tasmania emphasises that facts observed for large occurrences cannot be indefinitely extended downwards. However, when we turn to world-wide movements of sea-level we see a remarkable concordance between the Tasmanian shore line and features described in Professor Daly's chapter on High Sea Levels of the Pleistocene. (Compare Professor Daly's fig. 95 with Professor David's pl. XI in Pap. & Proc. Roy. Soc. Tas., 1923 (1924).)

One of the most outstanding features of Tasmanian glaciation, and a most baffling one which has caused much delay in the formulation of general descriptions,

is the alternation in the same valley of glaciated and waterworn tracts. In some of the most splendid examples of glacial valleys, for example, the Gordon, King, and Pieman Rivers, there are enormous waterworn gorges between obviously glaciated stretches, and the ice which eroded the lower glacial valleys must by force of topography have passed through the waterworn portions of the valleys. The amount of post-glacial river erosion in some places has been very considerable. The gorge on the King River is 3000 ft. deep and about 10 miles long. It shows no signs of glaciation. This is only typical of most glacial valleys. The most probable explanation is that it is only the present surface features which show typical river erosion. The whole valley must once have been glaciated. In certain localities governed entirely by slope, post-glacial rivers and their tributaries have removed the superficial features of ice erosion and remodelled the details of the topography to a waterworn one. (Lewis, Aust. Geographer, 1936.)

An associated feature, and quite a common one, is that of two parallel valleys, the higher typically glaciated, the lower waterworn. In the type locality east of Malanna, the Henty River flows over morainic material, while some five miles farther south the Yolande flows in a gorge entirely waterworn and some 450 ft. deeper than the bed of the Henty. On the Central Plateau where the ice tongues were thinner and spread out over relatively flat country, marked gorges up to 120 ft. deep often run alongside the lines of the glacial tongues, so that moraines and glacial features occupy the low dividing ridges and the small valleys are waterworn.

It appears clear that in many places ice fed streams were at work before the ice disappeared. In the stage of retreat the ice remained for a very long time stationary and dwindling, protected the underlying landscape rather than eroding it, while near by a very active stream was engaged eroding back into the névé country far beyond the margin of the ice. Many lakes that have been drained in this way exist round the sides of many glacial valleys with waterworn troughs, what may be called hanging moraines. The most outstanding is the Gormanston moraine referred to in the present writer's paper 'A Record of Varved Shales from Tasmania'.

Bibliography

Benson, W. N., 1917.—*Geology of Crade Mt.* (Proc. Roy. Soc. Tas., 1916 (1917), p. 34.) An excellent description of a typical area on the western edge of the Central Plateau.

Clemes, W. H., 1925.—*Geology of Lake St. Clair District.* (Proc. Roy. Soc. Tas., 1924 (1925), p. 59.) Description of the most impressively glaciated area in Tasmania.

David, T. W. E., 1924.—*Antiquity of Man in the Commonwealth.* (Proc. Roy. Soc. Tas., 1923 (1924), p. 109). A most important contribution and the basis for much subsequent work, although more recent field work involves some modification of conclusions.

———————, 1924.—*Pleistocene Glaciation near Strahan, Tasmania.* (Report Aust. Association Advancement Science 17, pp. 91-103.) Discussion and correlation of deposits and erosional surfaces. Useful bibliography.

Edwards, A. B., 1939.—*The Age and Physiographical Relationships of some Cainozoic Basalts in Central and Eastern Tasmania.* (Proc. Roy. Soc. Tas., 1938 (1939), pp. 175-199.) Suggests possible age-relationship of glaciation and basalt effusions in the Great Lake area.

———————, 1941.—*The North-West Coast of Tasmania.* (Proc. Roy. Soc. Vic., 53 (NS), Pt. II, 1941, p. 233.) This paper is the most detailed and useful account of sea coastline. It is not particularly directed to the study of Pleistocene glaciation but it records field evidence which will be most useful for wider generalization.

Gregory, J. W., 1903-4.—*Geography of Tasmania.* (Proc. Roy. Soc. Vic., 1903, p. 181; Quart. Journ. Geol. Soc. (Lond.), 1904, p. 37.) Stimulating ideas at the time and a basis for subsequent work but now largely superseded and time conclusions not substantiated.

Hills, Loftus, 1914.—*The Jukes-Darwin Mining Field.* (Geol. Surv. Tas. Bull. No. 16, pp. 14-18 and 57-58.) An excellent description of a typical area in the western ranges.

JOHNSTON, R. M., 1894.—*Glacial Epoch of Australia.* (Proc. Roy. Soc. Tas., 1893 (1904), p. 96 and p. 135.) A summary of early discoveries and a record of Johnston's work and opinions. Most valuable for its descriptive accounts but opinions largely superseded by later accounts.

LEWIS, A. N., 1922.—*Glacial Remains in the National Park.* (Proc. Roy. Soc. Tas., 1921 (1922), p. 16.) The longest and most detailed description of glaciation on one mountain group.

————, 1923.—*Topography of Lake Fenton.* (Proc. Roy. Soc. Tas., 1922 (1923), p. 32.) An additional observation added to 1921 paper describing an interesting feature in lake formation.

————, 1924.—*Geology of Mt. Anne and Weld Valley.* (Proc. Roy. Soc. Tas. 1923 (1924, p. 9.) First development of idea of three distinct glaciations. Description of a south-western mountain. Origin of button grass plains.

————, 1925.—*Geology of La Perouse.* (Proc. Roy. Soc. Tas., 1924 (1925), p. 9.) Description of most southerly mountain. First development of idea of Tertiary uplifts. Continuation of theory of separate glaciations.

————, 1933.—*Origin of the Great Lake.* (Proc. Roy. Soc. Tas., 1932 (1933), p. 15.) Description of an economically important geographical feature and discussion of problems in marginal area on largest plateau.

————, 1935.—*Glacial Features in D'Entrecasteaux Valley.* (Proc. Roy. Soc. Tas., 1934 (1935), p. 87.) Description of superimposed moraine.

————, 1936.—*Varved Shales from Tasmania.* (Australian Geographer, 1936, Vol. II, No. 8, p. 30.) First record of varved shales.

————, 1934-39.—*Correlation of Glacial Epochs.* (Proc. Roy. Soc. Tas., 1933 (1934), p. 67, 1934 (1935), p. 75, and 1938 (1939), p. 161.) The present writer's record of the field work and conclusions thereon which forms the basis of current ideas.

MAHONEY, D. J., 1943.—*The Problem of Antiquity of Man in Australia.* (Memoirs of Nat. Mus. Melb., No. 13, 1943.) Incidental remarks with a wide Australian correlation. Perhaps too generalized to be regarded as the final word but a useful summary of existing ideas.

MOORE, T. B., 1894-97.—*Discoveries of Glaciation.* (Proc. Roy. Soc. Tas., 1893 (1894), p. 147, 1894 (1895), p. 56, 1895 (1896), p. 73, 1896 (1897), p. xxi.) Interesting accounts of local discoveries with the earliest identification of two distinct phases. See this present writer's note, Proc. Roy. Soc. Tas., 1938 (1939), p. 172.

REID, A. M., 1918.—*The Mt. Pelion Mineral District.* (Geol. Surv. Tas. Bull. No. 30, pp. 14-17.) The best published description of the features of plateau glaciation.

————, 1919.—*The North Pieman, Huskinson, and Stirling Valley Mining Fields.* (Geol. Surv. Tas. Bull. No. 28, pp. 15-17, 41-42.)

TAYLOR, GRIFFITH, 1922.—*Geographical Notes on National Park.* (Proc. Roy. Soc. Tas., 1921 (1922), p. 188.) Interesting views on the cause of a feature now recognized as a double glaciation.

Pap. & Proc. Roy. Soc. Tasmania, 1944 (31st December, 1945)

Some Abnormal Conditions of the Reproductive System of the Saltwater Crayfish, *Jasus lalandii* (Milne Edwards)

By

V. V. Hickman

Ralston Professor of Biology, University of Tasmania

(Read 13th November, 1944)

Plates VI and VII

During the examination of a large number of crayfish, *Jasus lalandii* (Milne Edwards), caught off the south-east coast of Tasmania, several specimens exhibiting abnormal conditions of the reproductive system were observed. These are recorded and briefly described hereunder.

A Pseudo-hermaphrodite

Instances of hermaphroditism in Decapodan Crustacea have been discussed in some detail by W. P. Hay (1905) and S. Runnström (1925). A case of pseudo-hermaphroditism in a specimen of *Jasus lalandii* taken in South African waters was described by C. von Bonde in 1937. Externally the crayfish exhibited female characters on the left side and male characters on the right side, but internally only female features were evident.

The specimen described in the present paper was caught at Wedge Bay, Tasman Peninsula, by Mr. G. L. Spaulding on 15th June, 1937. It was of moderate size, having a total length of 293 mm., a carapace length of 113 mm., and a weight of 744 grammes. In most of its external features it resembled a male. The cephalothorax and abdomen had the same form as in a male and the fifth pair of pereiopods ended in a simple non-chelate claw. The specimen was remarkable, however, in having no genital apertures. The coxopodites of both the third and the fifth pairs of pereiopods showed no signs of any gonopore ever having developed (Pl. VII, fig. 5).

The abdominal appendages or pleopods exhibited an interesting combination of male and female characters. The exopodites of the appendages on the second, third, fourth, and fifth abdominal segments were small and leaf-like, resembling those of a normal male. The endopodites, however, instead of being absent as in a male, were present and resembled those of a female, but were on a much smaller scale. Thus the endopodites of the pleopods on the second abdominal segment were small and leaf-like, while those on the pleopods of the third, fourth, and fifth abdominal segments were rod-like and provided with long setae (Pl. VI, figs 1 and 2).

Dissection showed that the internal organs, excepting those of the reproductive system, were normal. The gonads, however, had the appearance of enlarged testes. On the right side of the body a vas deferens arose from the gonad in the usual position and, after forming an irregular coil, ended blindly without extending down to the coxopodite of the fifth pereiopod. On the left side of the body no genital duct was present (Pl. VI, fig. 3).

Serial sections cut longitudinally through a small portion of the gonad revealed the presence of both ova and spermatozoa (Pl. VI, fig. 4).

The crayfish was therefore very different from the South African pseudo-hermaphrodite, which, according to von Bonde (1937, p. 830), had a gonad, which showed the typical ovarian structure of the female.

Female with only one Genital Aperture

A female crayfish caught at Wedge Bay on 10th July, 1937, was found to have only a single genital aperture. This was situated in the normal position on the coxopodite of the third pereiopod of the right side. There was no genital aperture on the corresponding coxopodite of the left side (Pl. VII, fig. 6).

The specimen was 'in berry' and had a total length of 284 mm., a carapace-length of 109 mm., and a weight of 701 grammes. The eggs, after removal from the pleopods, weighed 63·9 grammes, the total number of eggs carried being about 281,000.

On dissection the ovary was found to be normal in shape and size, but the oviduct of the left side ended blindly in a small bulbus expansion in the coxopodite of the third pereiopod.

The absence of a genital aperture on the left side must have made the process of egg-laying somewhat difficult. It was obvious, however, from the large number of eggs carried and the collapsed condition of the gonad, that eggs formed in the left ovary had passed across the transverse bridge to the right ovary in order to reach the exterior by way of the single genital opening on the right side. Only a few eggs had remained unlaid in the ovary on the left side. These were undergoing absorption and were collected in a bend of the gonad near its junction with the blind oviduct.

Von Bonde (1937, p. 829) records a South African specimen 'having only a single genital aperture situated on the coxopodite of the pereiopod of the left side . . . . The left ovary was normally developed and was connected by an oviduct to the genital aperture. The right ovary, however, had a twisted appearance and was somewhat smaller than the left one. Also there was no oviduct on the right side'.

A Female with an extra Genital Aperture

Instances of Decapoda having abnormal genital apertures have been described by Bateson (1894), Marshall (1902), and Ridewood (1909).

The specimen described in the present paper was a female caught at Wedge Bay, 21st July, 1940. The crayfish was 'in berry'. It had a total length of 254 mm., a carapace-length of 93 mm., and a weight of 460 grammes. The total weight of eggs carried on the pleopods was 47·5 grammes.

The additional genital aperture was situated on the coxopodite of the fourth pereiopod of the left side (Pl. VII, fig. 7). On dissection, the ovary was found to be quite normal. A pair of oviducts led to the genital apertures on the coxopodites of the third pereiopods. There was no duct leading to the accessory aperture, which was closed.

Females with Abnormal Ovaries

In a normal female the reproductive system consists of paired ovaries, one on each side, extending from the region of the stomach to the first abdominal segment. The two ovaries are connected by a transverse bridge which crosses over the gut a short distance behind the stomach and is anterior to the oviducts.

A female caught at Wedge Bay on 6th February, 1939, exhibited an unusual condition of the ovaries. Externally the specimen was quite normal. It had a total length of 297 mm., a carapace-length of 112 mm., and a weight of 716 grammes. On dissection it was found that the left and right ovaries, in addition to being connected by the normal transverse bridge in front of the oviducts, were also joined together by a distinct fusion a short distance behind the oviducts (Pl. VII, fig. 8). The appearance of the fusion seemed to indicate that the posterior ends of the ovaries had crossed over each other and become intimately united at the intersection.

Another female taken at the same locality on 24th November, 1941, exhibited a similar fusion of right and left ovaries behind the oviducts. In this case, however, the union appeared to have been brought about without a crossing over of the two organs. In other respects the crayfish was quite normal. It had a total length of 264 mm., a carapace-length of 97 mm., and a weight of 532 grammes.

My thanks are due to Mr. A. M. Olsen, B.Sc., for assistance in searching literature not available in Tasmania. I am also indebted to the Trustees of the Ralston Bequest under whose auspices the above work was carried out.

References

Bateson, W., 1894.—Materials for a study of variation. London.

Hay, W. P., 1905.—Instances of hermaphroditism in Crayfishes. *Smithsonian Inst. Misc. Collect.* Washington, 48, pp. 222-228.

Marshall, F. H. A., 1902.—On the variations in the number and arrangements of the male genital apertures in *Nephrops norvegicus*. *Proc. Zool. Soc.* London. I, pp. 2-12.

Ridewood, W. G., 1909.—A case of abnormal oviducts in *Homarus vulgaris*. *Ann. Mag. Nat. Hist.* Ser. 8, Vol. 3, pp. 1-7.

Runnström, S., 1925.—Beitrag zur Kenntnis einiger hermaphroditischen dekapoden Crustaceen. *Bergens Mus. Skrift.* N.R. 3, No. 2, pp. 1-115, 5 pls.

von Bonde, C., 1937.—A case of pseudo-hermaphroditism in the Cape Crawfish, *Jasus lalandii* Ortmann, with a note on Decapodan Hermaphroditism. *South African Journal of Science* 33, pp. 827-832, pls. XI-XIV.

PLATE VI

Jasus lalandii (Milne Edwards)

FIG. 1.—Left pleopod of second abdominal segment of pseudo-hermaphrodite. *en.* endopodite, *ex.* exopodite.

FIG. 2.—Left pleopod of third abdominal segment of pseudo-hermaphrodite. *en.* endopodite, *ex.* exopodite.

FIG. 3.—Gonads of pseudo-hermaphrodite showing abnormal vas deferens on right side.

FIG. 4.—Section through portion of gonad of pseudo-hermaphrodite. *ov.* developing ova; *sp.* groups of spermatozoa in a mass of secretion; *spc.* spermatocytes.

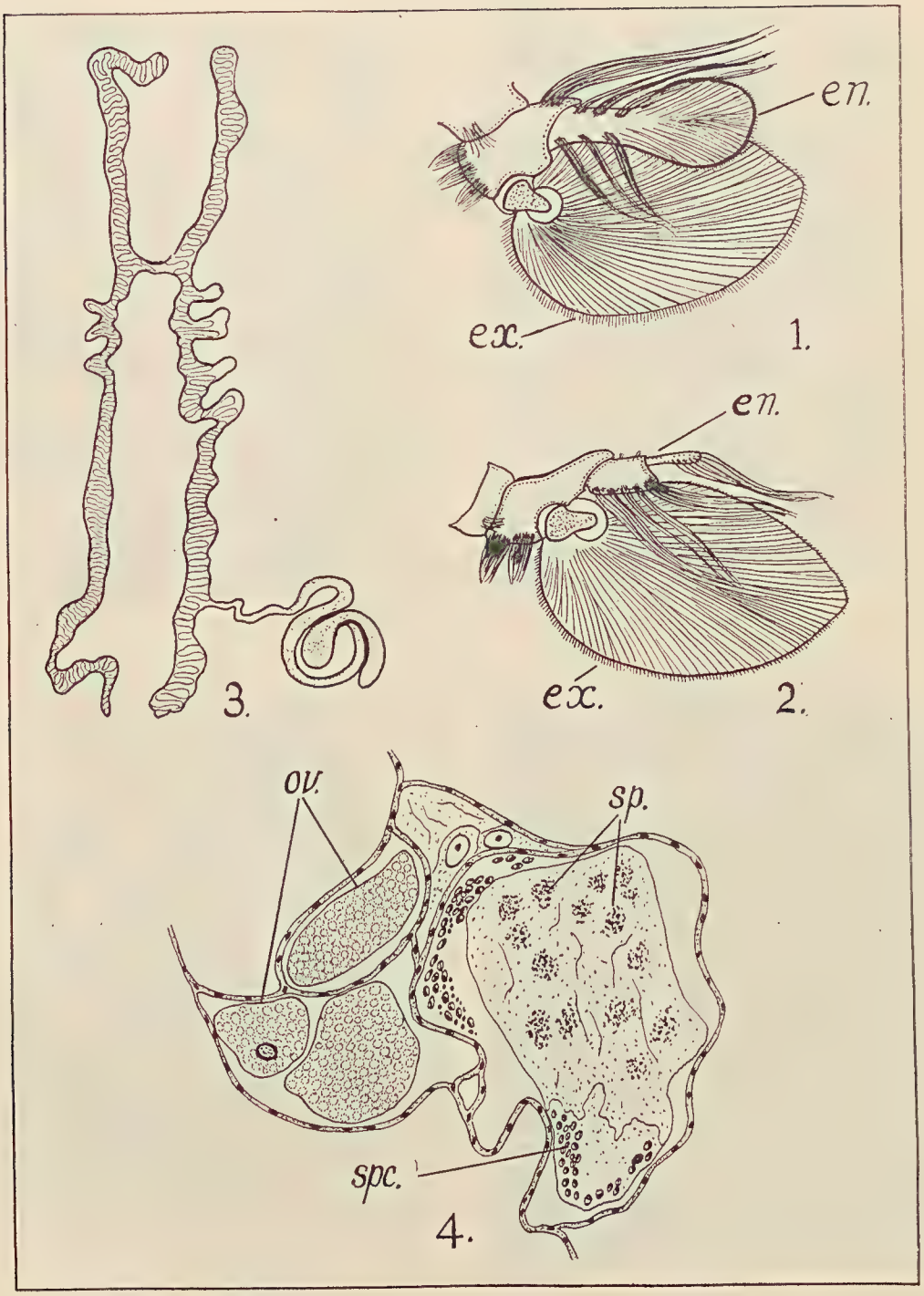

en.
ex.
1.
en.
ex.
2.
3.
ov.
sp.
spc.
4.

PLATE VII

Jasus lalandii (Milne Edwards)

FIG. 5.—Sternum and bases of pereiopods of pseudo-hermaphrodite showing absence of genital apertures.

FIG. 6.—Sternum and bases of pereiopods of female having a single genital aperture, which is visible on the third right coxopodite.

FIG. 7.—Sternum and bases of pereiopods of female with an extra genital aperture, which is visible on the fourth left coxopodite.

FIG. 8.—Reproductive organs of female showing an abnormal fusion of right and left ovaries.

Fig. 5

Fig. 6

Fig. 7

Fig. 8

New Trematodes from Tasmanian Fishes (Order, Digenea. Family, Allocreadiidae)

By

P. W. Crowcroft

Demonstrator in Biology, University of Tasmania

(Read 13th November, 1944)

Plates VIII, IX

Little is known concerning the trematode parasites of Tasmanian fishes. A single species *Coitocaecum anaspidis* Hickman has been described from progenetic metacercariae in the Mountain Shrimp, *Anaspides tasmaniae* Thompson. Members of the genus *Coitocaecum* usually complete their life cycle in a fish. The present paper discusses the status of species belonging to the genus, and describes a new species, *Coitocaecum parvum*, from specimens of the freshwater fishes, *Galaxias attenuatus* Jenyns, and *Pseudaphritis urvillii* (Cuv. and Val.), caught in a brackish creek near the Bowen Monument at East Risdon.

In addition to the above, a new trematode from the purple banded parrot fish, *Pseudolabrus tetricus* Rich., is described. The species forms the type of a new genus, and the name *Gnathomyzon insolens* gen. et sp.n. is proposed.

For whole mounts specimens were fixed in 90% alcohol under slight cover-glass pressure, and stained in borax-carmine or Ehrlich's haematoxylin. For sectioning specimens were fixed in Bouin's solution and the sections were stained in Ehrlich's haematoxylin.

Family ALLOCREADIIDAE

Sub-family *OPECOELINAE* Manter.

Genus **Coitocaecum** Nicoll

The genus *Coitocaecum* was founded by Nicholl (1915) for a single species, *Coitocaecum gymnophallum*. Nicoll was uncertain of the relationship of the new genus to the Allocreadiidae, but considered that the absence of a true cirrus pouch, and the fused condition of the intestinal rami posteriorly, to form a continuous arch, excluded it from that family. Poche (1925) created the sub-family Coitocaecinae of the Allocreadiidae to contain the genus. Ozaki (1925) assigned the genus to his new family Opecoelidae. Four years later Ozaki described

C. plagiorchis, C. orthorchis, C. unibulbosum, C. diplobulbosum, and *C. latum,* and founded the family Coitocaecidae to contain these and Nicoll's species. Ozaki separated *Coitocaecum* from the Opecoelidae because of the absence of an anus in the former. Iwanitsky (1928) described *C. skrjabini,* but the original description is not available in Australia. However, a brief account of the species was given by Pigulevsky (1931) in a paper on the fish trematodes of the Dnjepr basin. In this same paper *C. macrostomum* and *C. ovatum* were also described. Wisniewsky (1932) described *C. testiobliquum* from normal adult and progenetic specimens. The progenetic metacercariae occurred in the haemocoele of *Fontogammarus bosniacus* (Schäf.) and *Rivulogammarus spinicaudatus* (Schäf.). Wisniewsky (1934) described *C. proavitum,* and divided the known species of the family Coitocaecidae Ozaki into three genera, naming the two new genera *Ozakia* and *Nicolla.* Unfortunately, the paper is not obtainable in Australia, but an abstract gives *C. plagiorchis* Ozaki as the type species of the genus *Ozakia,* and *C. ovatum* Pigulevsky as the type of the genus *Nicolla.* The present writer considers that, in view of the uniformity of the species of the genus *Coitocaecum,* the splitting appears unjustified, but until Wisniewsky's paper is examined the proposed genera cannot be adequately discussed.

Hickman (1934) described *C. anaspidis* from the progenetic metacercariae encysted in the haemocoele of *Anaspides tasmaniae* Thompson, the normal adult being unknown. Yamaguti described *C. glandulosum* in the same year, and stated that he had re-examined *C. gymnophallum* Nicoll, and found that Nicoll was mistaken in his assertion that no true cirrus pouch was present in that species. Yamaguti separated *C. glandulosum* from *C. gymnophallum* because of the presence of large gland cells in the vicinity of the anterior intestinal arch, which were not mentioned in Nicoll's description of *C. gymnophallum.* There was also a difference in egg size. *C. glandulosum* Yamaguti must be retained pending re-examination of Nicoll's material.

Stunkard (1931) regarded Ozaki's removal of *Coitocaecum* from the Opecoelidae as unjustified, since the presence or absence of an anus in the Digena was not as important a diagnostic character as previously thought. Stunkard favoured the inclusion of *Coitocaecum* with *Opecoelus,* and *Anisoporus,* in the family Opecoelidae, but pointed out that a better course might be to reduce the family Opecoelidae to a sub-family of the Allocreadiidae. Manter (1934) set up the sub-family Opecoelinae to include the four genera and dropped the families Opecoelidae Ozaki and Coitocaecidae Ozaki. Harshey (1937) following Manter adopted this classification.

Wu (1937) briefly described a *Coitocaecum* sp., encysted in shrimps from the Shanghai region and maturing in fresh water fishes. Immature stages were also reported from toads. A detailed description has not yet appeared and the species is so far unidentified. Macfarlane (1939) described the life history of a trematode which he identified as *Coitocaecum anaspidis* Hickman. The trematode occurred as a normal adult in *Gobiomorphes gobioides* Cuv. and Val., *Salmo fario* Linn., *Galaxias brevipennis* Günther, *Galaxias attenuatus* Jenyns, and in eels, and as a progenetic metacercaria in *Potamopygus* species and *Paracalliope fluviatilis* (Thompson). A description of the adult form was given to illustrate the differences that Macfarlane found between the New Zealand specimens and Hickman's description of the progenetic metacercaria. The differences were not discussed and no adequate comparison of the New Zealand progenetic metacercaria with Hickman's description was made. Wisniewsky (1933) found no significant differences between the progenetic metacercaria and normal adult of *C. testiobliquum,* except that the normal adult was slightly larger than the progenetic form. Consequently in another species of the same genus, significant differences are not expected to occur between the normal adult and the progenetic metacercaria. Nor

should differences occur between progenetic individuals from Tasmanian and New Zealand crustacea. However, a critical examination of the two papers shows the following differences:

(1) The vitellaria in *C. anaspidis* extend into the neck region, as far forward as the level of the genital pore. As the pore lies near the hind end of the long oesophagus, the foremost extent of the vitellaria is well behind the pharynx. The written description of the New Zealand specimens agrees with this, but the illustration shows the vitellaria extending forward beyond the genital pore to the level of the pharynx. An error is more likely in the text than in the figure, so that the distribution of the vitellaria in the New Zealand trematode appears to differ from that of *C. anaspidis.* The extent and distribution of the vitellaria is regarded as an important diagnostic character in the genus.

(2) Minor differences are noticeable in the descriptions of the reproductive system. In *C. anaspidis* Laurer's canal runs across the body, loops upon itself and opens by a dorsal pore situated just to the left of the mid-line. In Macfarlane's description the canal runs directly across to a dorsal pore situated well to the left of the body. A well developed prostate gland composed of large spindle shaped gland-cells is present in the New Zealand post metamorphic metacercaria, but no distinct prostate gland occurs in the Tasmanian form. Also, the ovary is nearly spherical giving off the oviduct anteriorly in *C. anaspidis,* but the New Zealand form has a pear-shaped ovary which leads into the oviduct laterally.

(3) Progenetic metacercariae taken from the haemocoele of *Paracalliope fluviatilis* had immature testes and hence give rise to miracidia parthenogetically. Metacercariae taken from *Anaspides tasmaniae,* however, possess abundant mature sperms in the seminal vesicle and receptaculum seminis uterinum, so that it is probable that the miracidia are formed from fertilized ova.

(4) Hickman's specimens measured 2·4-2·8 mm. long. The progenetic metacercariae from New Zealand measured 1·5-2·00 mm. long.

In view of the differences between the original description of the species, and Macfarlane's account of the New Zealand form, the identity of the latter must be in doubt until material from both sources is available to the one investigator.

In 1940, Manter described *C. tropicum* from the Galapagos Islands and Yamaguti, continuing his studies on the helminth fauna of Japan, described *C. xesuri* and *C. leptoscari.* Yamaguti considered that *C. diplobulbosum* Ozaki and *C. unibulbosum* Ozaki were described from specimens of the one species in different stages of contraction. Ozaki separated the two forms principally because of the constricted pharynx and longer oesophagus of the former. The present writer does not consider these characters variable to such an extent that Ozaki's two descriptions could apply to the one species, and retains *C. diplobulbosum* Ozaki and *C. unibulbosum* Ozaki. *C. xesuri* Yamaguti was described from a single example and differs from *C. unibulbosum* Ozaki in its larger size, and slight differences in the position of the acetabulum and testes. This example may not represent a distinct species, but if further specimens exhibiting the same differences from *C. unibulbosum* are obtained, the species *C. xesuri* Yamaguti might be acceptable.

A description of *C. tropicum* Manter is not available in Australia.

Coitocaecum parvum, sp.n.

(Plate VIII, fig. 1, and Plate IX, figs 3 and 4)

Trematodes of small but variable size, the average dimensions being 0·86 mm. long and 0·34 mm. wide, under slight cover glass pressure. The length of individual specimens varies from 0·57-1·8 mm. The worms are of long oval shape

with a tapered anterior end, and are broadest in the vicinity of the acetabulum or just behind that organ. In section the body is slightly flattened dorso-ventrally. The acetabulum is relatively large and strongly muscular. It is situated in the posterior of the anterior half of the body, and measures approximately 0·19 x 0·14 mm. The inner surface of the gape may be papillate. The oral sucker is sub-terminal and measures about 0·09 mm. in diameter.

The living trematodes are of a white translucent appearance, and of a yellowish colour in the regions of the vitellaria. The principal organs, vitellaria, testes, ovary, and alimentary system can readily be seen when the animal is viewed by transmitted light. A change in the proportions of the body takes place as the young adults mature. Very young specimens are broadest in the region of the testes, and the acetabulum is situated about the middle of the body. Older specimens show elongation of the body behind the acetabulum accompanied by relative enlargement of the testes.

The oral sucker leads by a very short prepharynx into the globular muscular pharynx, which measures 0·48-0·72 mm. long and 0·44-0·76 mm. in diameter. This is followed by the oesophagus, the length of which varies greatly according to the general state of contraction of the specimen. The average length of the oesophagus is about 0·04 mm. It has a fairly stout muscular wall composed of inner circular and outer longitudinal muscles. The hind portion of the pharynx and the whole length of the oesophagus are surrounded by gland cells. The oesophagus joins the intestine, the two rami of which are simple and tubular and run backwards laterally, to unite below the excretory vesicle forming a continuous arc. The posterior intestinal arc lies along the posterior edge of the hind testis. There is no connection between the intestine and the excretory vesicle.

The common genital pore opens on the ventral surface to the left and just anterior to the intestinal fork. The testes are two large lobed bodies lying in tandem or oblique fashion, within the posterior intestinal arch. The hind testis is frequently larger than the anterior. They measure approximately 0·16 x 0·09 mm. and 0·17 x 0·1 mm. respectively. The vasa deferentia are given off anteriorly and run forward to the base of the seminal vesicle, where they unite. The seminal vesicle lies within the anterior intestinal arch, dorsal to the acetabulum, and to the left of the mid-line. It crosses the left ramus of the intestine just below the fork. The vesicle is sac-like and may extend backwards to the posterior edge of the acetabulum, but is frequently shorter. It measures about 0·16 mm. long. Anteriorly the vesicle tapers and enters the cirrus sac, where it passes over into the ejaculatory duct. The seminal vesicle thus lies entirely outside the cirrus pouch, with the exception of the short tubular portion leading to the ejaculatory duct. The ejaculatory duct is coiled once before leading into the common genital atrium. The terminal portion is thickened to form a small unarmed cirrus. The cirrus sac is pear-shaped, being narrow where it joins the seminal vesicle, and expanded to contain the anterior coiled portion of the ejaculatory duct. The sac measures 0·064 mm. long and 0·032 mm. broad at the broad anterior region. Its wall is thin but muscular, being composed of inner circular and outer longitudinal muscles. Scattered darkly staining cells forming the prostate are present in the anterior of the sac. There appears to be no distinct pars prostatica.

The ovary is ovoid and lies on the right side of the body directly in front of, or obliquely to, the anterior testis. It measures approximately 0·09 x 0·06 mm. Anteriorly and dorsally the ovary tapers into the oviduct. The oviduct passes dorsally and divides, one branch leading into the ootype, the other running across the body as Laurer's canal. The canal forms a ventrally directed loop, and opens on the dorsal surface by a pore situated to the left of the mid-line, at the level of the yolk reservoir.

The ootype is situated about in the mid-line of the body and passes into the uterus, which describes a few intercaecal turns before turning forward over the left side of the acetabulum. When the proximal portion of the uterus is not distended with eggs a slightly expanded receptaculum seminis uterinum containing sperms can be seen a short distance from the ootype. Anteriorly, the uterus, together with the seminal vesicle, passes under the left ramus of the gut and ends in a well developed metraterm. This lies above the cirrus sac, and opens into the common genital atrium, just in front of the male aperture. The eggs are ellipsoid, light brown in colour, and measure 0·06-0·076 x 0·032-0·04 mm. The number of eggs present in the uterus is usually few, only five, six or seven being found in small specimens, but in larger individuals the uterus may contain twenty or more eggs. In small specimens the eggs appear relatively enormous. They have an operculum, 0·016 mm. diameter, at one end. No filament is present.

The yolk follicles are numerous, and extend laterally from the level of the pharynx to the posterior region of the body, where they fill the body behind the testes. Laterally the follicles lie above, below, and external to the gut rami, occasionally surrounding them completely. Their shape varies, but is generally ovoid, measuring 0·036-0·048 mm. in greatest diameter. Anterior and posterior collecting ducts, on each side, fuse in a transverse duct. In the mid-line, or slightly to the right of the mid-line, the transverse ducts enter the spindle-shaped yolk reservoir. The median yolk duct leaves the reservoir antero-dorsally, runs directly dorsally and then turns and enters the ootype laterally (Pl. IX, fig. 3). A group of shell glands surrounds the yolk duct where it joins the ootype.

The excretory vesicle is large and club shaped. It opens at the excretory aperture situated in the mid-line of the posterior border of the body, and extends forward as far as the yolk reservoir. Near the anterior extremity of the vesicle two main collecting ducts arise. These ducts run forward beneath the rami of the gut into the neck region.

Hosts. *Pseudaphritis urvillii* (Cuv. and Val.). *Galaxias attenuatus* Jenyns.

Locality. Creek, near Bowen Monument, Risdon (April, 1944).

Type. It is proposed to deposit the type specimen in the Sydney Museum.

Affinities

The general characters of the trematode place it at once in the genus *Coitocaecum* Nicoll. It seems to be most closely related to *C. anaspidis* Hickman. The present writer agrees with Stunkard, Harshey, and Manter that the absence of an anus and the minor differences from *Opecoelus* are not sufficient reasons for removing *Coitocaecum* from the Opecoelidae. Further, that the family Opecoelidae should be abandoned and the genera in that family included with *Coitocaecum* in the sub-family Opecoelinae Manter (1934) of the Allocreadiidae.

Key to Coitocaecum Species

1. Vitellaria entirely postacetabular 2
   Vitellaria extend into neck but are broken at the level of the acetabulum 3
   Vitellaria reach the top edge of the acetabulum or extend into the neck, but not broken at the level of the acetabulum 4
2. Large gland cells present in the vicinity of the anterior intestinal arch .... *C. glandulosum* Yamaguti
   Large gland cells not present .... *C. gymnophallum* Nicoll
3. Body broad oval, testes transversely elongate and in tandem, hind testis smaller .... *C. testiobliquum* Wisniewsky
   Body elongate oval testes roundly lobed, and oblique, hind testis larger .... *C. ovatum* Pigulevsky

4. Genital aperture median, cirrus sac within intestinal arch .... *C. macrostomum* Pigulevsky
   Genital aperture to one side of the mid-line, seminal vesicle crossing intestine 5
5. Oral sucker almost as large as acetabulum .... *C. skrjabini* Iwanitsky
   Oral sucker approximately half as large as acetabulum 6
6. Body round .... *C. latum* Ozaki
   Body ovoid or elongate oval 7
7. Pharynx constricted posteriorly .... *C. diplobulbosum* Ozaki
   Pharnyx globular 8
8. Vesicula seminalis interna spherical .... *C. plagiorchis* Ozaki
   Vesicula seminalis interna tubular 9
9. Posterior intestinal arch immediately behind the hind testis .... *C. parvum*, n.sp.
   Posterior intestinal arch near to posterior border of body 10
10. Cirrus sac completely muscular .... *C. leptoscari* Yamaguti
    Cirrus sac partly or entirely membranous 11
11. Cirrus absent .... *C. unibulbosum* Ozaki
    Cirrus present 12
12. Oesophagus short, cirrus sac entirely membranous .... *C. orthorchis* Ozaki
    Oesophagus long, cirrus sac muscular anteriorly .... *C. anaspidis* Hickman

Sub-family *ALLOCREADIINAE*

Gnathomyzon, gen.n.

Diagnosis. Small pyriform worms with a flattened elliptical cross-section. Integument spinous. Oral sucker sub-terminal. Acetabulum large, possessing a pair of lateral muscular gripping jaws. Intestinal limbs simple, tubular, reaching almost to the posterior edge of the body. Testes, one behind the other in the posterior third of the body. Ovary directly in front of anterior testis. A large receptaculum seminis present, lying transversely, and dorsal to the ovary. Laurer's canal long. External seminal vesicle large and tubular. Cirrus sac highly muscular, containing a large internal seminal vesicle. Diffuse prostate gland present. Definite pars prostatica absent. No true cirrus present. Coils of uterus few, intercaecal, and between acetabulum and ovary. Short metraterm present. Genital aperture to the left of the mid-line, slightly in front of the intestinal fork. Excretory vesicle tubular, bifurcating anteriorly.

Gnathomyzon insolens, sp.n.

(Plate IV, fig. 2, and Plate V, figs 5 and 6)

Small pyriform trematodes. Specimens fixed under slight cover-glass pressure measured 1·40-2·00 mm. long, and 0·61-0·94 mm. wide at their broadest region, this being in the posterior third of the body. The oral sucker is sub-terminal and measures 0·14-0·19 mm. diameter. The acetabulum measures 0·32 mm. diameter and is remarkable in that it possesses a pair of differentiated lateral thickenings or gripping jaws, which are present and identical in every specimen examined.

The living animal has a white translucent appearance, the prinicipal organs, testes, receptaculum seminis, ovary, vitellaria and cirrus pouch being visible in transmitted light. The cuticle is covered with minute spines, and the active mobile neck region of the body is leech-like in appearance.

The oral sucker is followed by a short prepharynx 0·1 mm. long, which leads into the strongly muscular pharynx which measures 0·08 mm. in diameter. The oesophagus is 0·08 mm. long. It has a fairly muscular wall and leads to the bifurcation of the gut, whence the two rami of the gut run backwards as simple unbranched tubes almost to the posterior end of the body. The bifurcation is mid-way between the pharynx and the anterior edge of the acetabulum. There is no connection between the gut and the excretory vesicle.

The two testes are transversely elongated and lies one behind the other in the posterior third of the body. Under slight cover-glass pressure they measure

0·44 x 0 13 mm. and are slightly lobed in outline. The very slender vas deferentia lead past the left side of the ovary, and meet at the posterior extremity of the seminal vesicle, which extends forward from just behind the acetabulum. Posteriorly it is large and sac-like, but narrows and passes over the acetabulum as a thin walled tube. At the anterior margin of the acetabulum the vesicle narrows and passes into the posterior end of the cirrus sac. Within the cirrus sac it expands into a large internal seminal vesicle, which in the turgid condition completely fills the cirrus sac except at the anterior end, where the vesicle narrows into a short ejaculatory duct leading into the genital atrium. The terminal portion of the ejaculatory duct is not thickened or armed to form a distinct cirrus, but from the appearance of the musculature at the anterior end of the cirrus sac, it seems to be protrusible. The ejaculatory duct and the tapered anterior end of the internal seminal vesicle are surrounded by numerous small gland cells whose long thin ducts can be seen leading through the muscular wall. There is no distinct pars prostatica. The cirrus sac extends from the level of the anterior edge of the acetabulum to the genital atrium, which is situated slightly to the left of the mid-line at the level of the posterior edge of the pharynx. The sac thus passes under the left branch of the gut near the bifurcation. It measures up to 0·13 mm. in diameter and 0·24 mm. long, and has a strongly muscular wall composed of a thick outer layer of longitudinal muscles and an inner layer of thick circular muscles.

The ovary is a transversely elongated ovoid body, slightly indented in outline, and lying against the anterior testis. It may be median or slightly displaced toward the right side of the animal. It measures 0·21-0·31 x 0·08-0·13 mm. Dorsally the ovary tapers into the oviduct, the proximal portion of which is expanded into a fertilization chamber. The oviduct then passes transversely and dorsally towards the left side, meeting a transverse passage, which expands on the right side into a large receptaculum seminis. On the left side, the transverse passage gives off the uterus ventrally and continues across the body as Laurer's canal. The latter forms a ventrally directed loop and returns to the dorsal surface to open at a pore situated to the left of the mid-line, at the level of the yolk reservoir. The uterus passes ventrally, receives the median yolk duct from the vitelline reservoir, and expands slightly to form the ootype, into which open a group of shell-glands having short wide ducts. The convolutions of the uterus are intercaecal and few in number. They lie between the acetabulum and the anterior testis, ovary, and receptaculum seminis. The uterus passes forward over the acetabulum slightly to the left of the mid-line, and lying above the cirrus sac, extends to the level of the genital pore. A short muscular metraterm passes ventrally to open into the common genital atrium in front of the male aperture. The circular muscles of the metraterm are continuous with those of the ejaculatory duct. The eggs are ellipsoid in form and the shell is dark brown in colour. They measure 0·056 x 0·032 mm. and possess an operculum 0·008 mm. in diameter at one end. No filaments are present.

The yolk follicles form a densely aggregated mass above, below, and external to the intestinal rami. They extend from the posterior of the body to about the level of the middle of the acetabulum, and also occupy the posterior region of the body behind the posterior testis. The follicles are somewhat angular in shape and vary in size from 0·048 mm. in diameter to 0·10 x 0·036 mm. The yolk is collected by tubules which unite into main right and left longitudinal ducts. The main longitudinal ducts of each side unite into the right and left transverse ducts, which pass dorsally and meet in the spindle-shaped reservoir situated to the left of the mid-line and slightly behind the ovary. From the left end of the reservoir a short duct runs forward to the uterus.

The excretory pore is situated on a sunken papilla in the middle of the posterior margin of the body. The excretory vesicle is simple and tubular, and extends from the pore to the posterior testis, above which it may extend forward for a short distance. The vesicle measures 0·3 mm. long, and 0·03 mm. diameter, and is lined with a glandular epithelium. At its anterior end it bifurcates into two main collecting tubes, which pass forward on either side of the hind testis within the dorso-ventral muscles. These main tubes run towards the dorsal surface for a short distance, pass downwards within the dorso-ventral muscles and come to lie below the rami of the gut. Fine collecting tubules open into the main tubes throughout their length.

Host. *Pseudolabrus tetricus* Rich.

Locality. Derwent Estuary, Tasmania (March, 1944).

Type. It is proposed to deposit the type specimen in the Sydney Museum.

Affinities

The general characters of the trematode place it in the sub-family Allocreadiinea of the Allocreadiidae, although it differs in that a prominent cirrus is not developed. The genus is distinguished by its peculiar ventral sucker. Manter (1934) described *Myzoxenus vitellosus*, from *Calamus calamus* (Cuv. and Val.) and *Decodon puellaris* (Poey), which possesses apparently similar gripping structures. Manter also mentions that a rather similar modification of the ventral sucker occurs in *Dolichosaccus amplicava* Travassos.

I wish to express my gratitude to Professor V. V. Hickman for his kind advice and encouragement, and for making the original slides of *C. anaspidis* available for comparative study. My thanks are also due to Mrs. B. Sikk for her willing assistance in translating from the Russian the descriptions of *C. ovatum*, *C. macrostomum*, and *C. skrjabini*.

References

Fuhrman, O., 1928.—Trematoda in Krumbach and Kühkenthal's "*Handbuch der Zoologie*," *2 Lief. 3. Berlin; de Gruyter.*

Harshey, K. R., 1937.—"On some new Trematodes with anus." *Proc. Ind. Acad. Sc. V.5, No. 2 Sec. B*, 64-75.

Hickman, V. V., 1934.—On *Coitocaecum anaspidis*, sp.nov., a Trematode exhibiting progenesis in the fresh water crustacean *Anaspides tasmaniae* Thompson. *Parasitology*, 26, 121-126.

Macfarlane, W. V., 1939.—Life cycle of *Coitocaecum anaspidis* Hickman, a New Zealand digenetic trematode. *Parasitology*, 31, 172-184.

Manter, H. W., 1934.—Some digenetic trematodes from Deep water Fish of Tortugas, Florida. *Carnegie Inst. Wash. Pub.* No. 435, p. 299.

————————, 1940.—Digenetic Trematodes from the Galapagos Islands and the neighbouring Pacific. *Rep. Alan Hancock Exped.*, 2, 14, 371-373.

Nicoll, M., 1915.—The Trematode parasites of North Queensland, Parasites of Fishes, i. *Parasitology*, 8, 22-40.

Ozaki, Y., 1929.—Note on Coitocaecidae, a new Trematode family. *Ann. Zool. Jap.*, 12, 75-90.

Pigulevsky, S. W., 1931.—Fischparasiten des Dnjeprbassins. *Annu. Mus. Zool. Acad.* Leningrad, 32, 439-443. (German summary, 451-452.)

STUNKARD, H. W., 1931.—Further observations on the occurrence of anal openings in digenetic Trematodes. *Z. Parasitenk.*, 3 (4), 713-715.

WISNIEWSKY, L. W., 1933.—Ueber zwei neue progenetische Trematoden aus den Balkanischen Gammariden. *Bull. Acad. Polon., Cracovie, Ser. B,* 1932 (1933), 260-268.

————————, 1934.—Beitrag zur Systematic der Coitocaecidae (Trematoda), Nicolla, g.n., Ozakia, g.n., Coitocaecum proavitum, sp.n. *Mem. Acad. Polon. Cracow, Class. Sc. Math. Nat. B,* 1934, 27-42.

WU, K., 1937.—Two encysted trematodes of fresh water shrimps around Shanghai region. *Peking Nat. Hist. Bull.,* 11 199-201.

YAMAGUTI, S., 1934.—Studies on the Helminth fauna of Japan, Trematodes of Fishes, i. *Japan. J. Zool., Tokyo,* 5, 357-359.

————————, 1940.—Studies on the Helminth fauna of Japan, Trematodes of Fishes, vii. *Japan. J. Zool., Tokyo,* 9, No. 1, 77-79.

PLATE VIII

FIG. 1.—*Coitocaecum parvum* (0·8 mm.), dorsal view.

FIG. 2.—*Gnathomyzon insolens* (2·00 mm.), ventral view.

Ac., acetabulum; CS., cirrus sac; Ex., excretory vesicle; ExAp., excretory aperture; GenAp., genital aperture; Int., intestine; Met., metraterm; Oes., oesophagus; OS., oral sucker; Ov., ovary; P Ph., pre-pharynx; Ph., pharynx; R Sem., receptaculum seminis; S Jaw., gripping jaw of acetabulum; Test., testes; Ut., uterus; VS., seminal vesicle; VSI., internal seminal vesicle; YkRes., yolk reservoir.

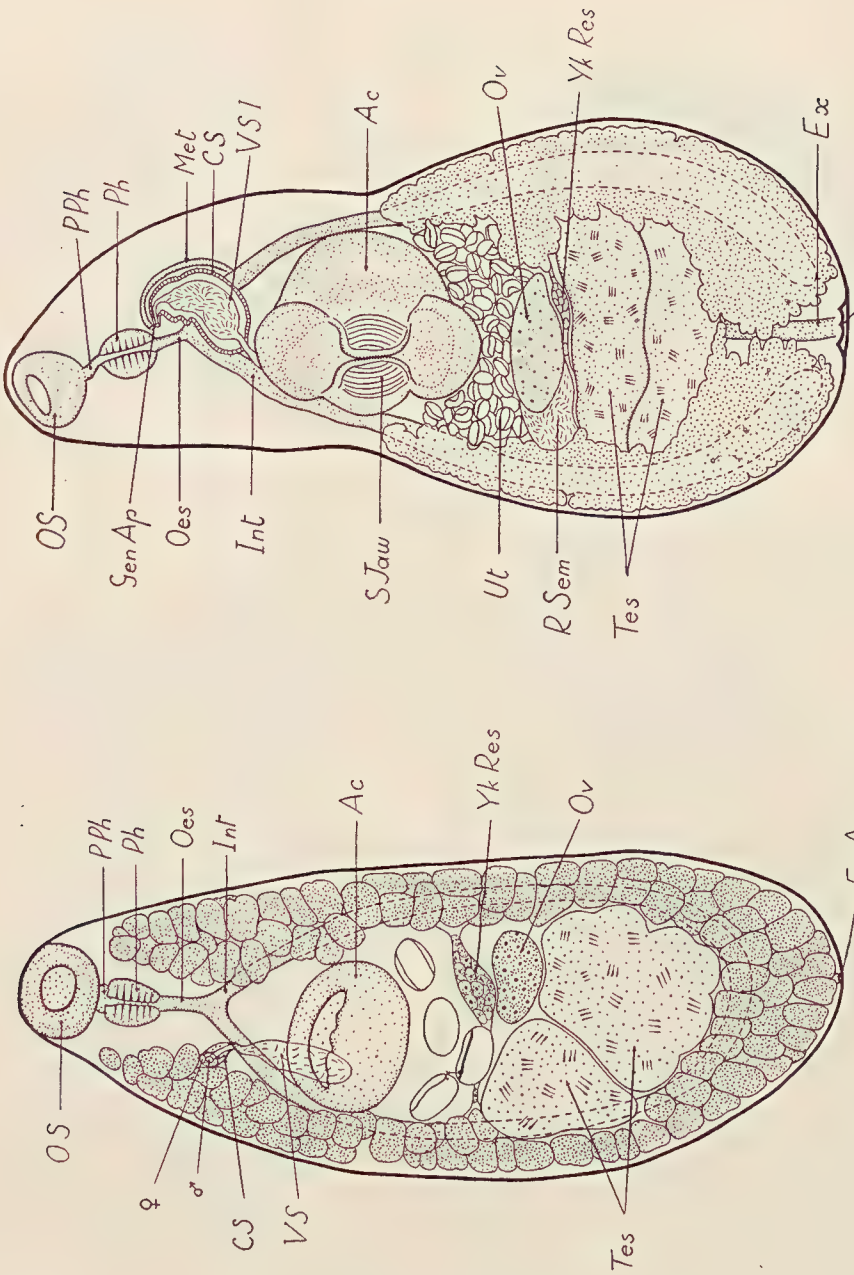

OS
PPh
Ph
Oes
Int
Ac
Yk Res
Ov
Ex Ap
♀
♂
CS
VS
Tes
1
OS
PPh
Ph
Met
CS
VS1
Ac
Ov
Yk Res
Ex
Ex Ap
Sen Ap
Oes
Int
S Jaw
Ut
R Sem
Tes
2

PLATE IX

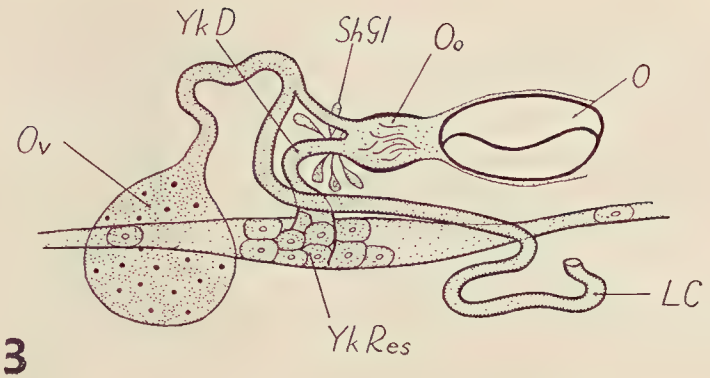
FIG. 3.—*Coitocaecum parvum*, dorsal view of female genital complex

FIG. 4.—*Coitocaecum parvum*, genital end organs in longitudinal section.

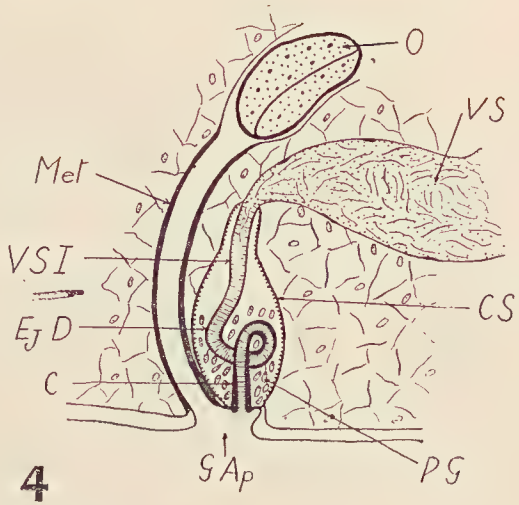
FIG. 5.—*Gnathomyzon insolens*, view of female genital complex from posterior aspect.

FIG. 6.—*Gnathomyzon insolens*, diagram of median longitudinal section through gripping jaw.

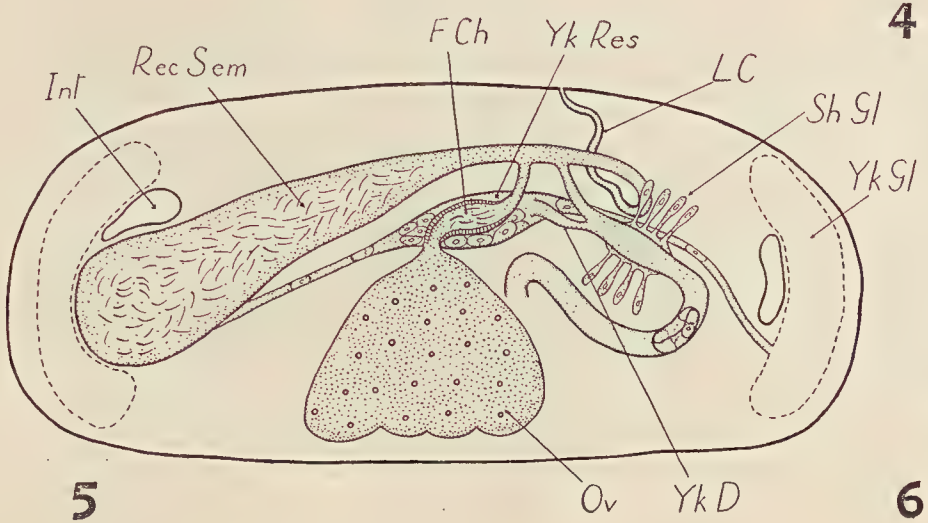
C., cirrus; Ejd., ejaculatory duct; F Ch., fertilization chamber; LC., Laurer's canal; Met., metraterm; O., ovum; Oo., ootype; PG., prostate gland; R Sem., receptaculum seminis; ShGl., shell gland; YkGl., extent of vitellaria. For remaining references see Plate VIII.


Yk D
Sh Gl
Oo
O
Ov
LC
Yk Res

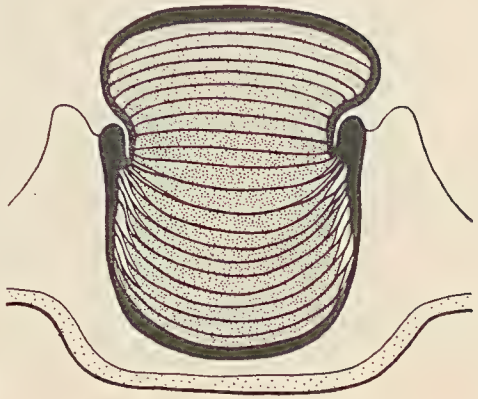
3


O
VS
Met
VS I
CS
Ej D
C
G Ap
P G

4


F Ch
Yk Res
Rec Sem
Int
LC
Sh Gl
Yk Gl
Ov
Yk D

5



6

Pap. & Proc. Roy. Soc. Tasmania, 1944 (31st December, 1945)

The Female Urogenital System of the Marsupialia with special reference to the Vaginal Complex

By

Joseph Pearson

(Read 13th November, 1944)

Plates X-XII

It is proposed to discuss the general disposition of the female urogenital organs in the Marsupialia and in particular to examine the variations to be found in the vaginal complex. Special reference will be made to the genera *Potoroüs* and *Bettongia*, partly because the urogenital system of the former has not been described or figured hitherto and also because the two genera have been confused by previous writers on marsupial comparative anatomy and it is important that the matter should be clarified once and for all (see Pearson, 1944).

The foundation of our knowledge of the urogenital system of the Marsupialia was well and truly laid by Richard Owen, and after the lapse of a century students of comparative anatomy of the group find themselves returning to the admirable and, on the whole, accurate accounts of the urogenital system which the distinguished comparative anatomist has placed on record.

A second stage may be said to have been reached when Lister and Fletcher (1881) and Fletcher (1882, 1883, 1884) made a careful investigation of the vaginal cul-de-sac of the Macropodidae and were able to confirm and supplement some of the observations on marsupial parturition which had first been made by Home as far back as 1795 and later by Owen, Alix (1879), Brass (1880) and others.

Perhaps the most fruitful period is associated with the name of J. P. Hill who since the concluding years of the last century has issued a series of monographs dealing with the comparative anatomy of the urogenital system and more particularly with the embryology of the Marsupialia. In the course of their anatomical researches Hill (1899, etc.) and Hill and Fraser (1925) have rounded off the earlier work and have demonstrated that the marsupials have forsaken the primitive parturient route by way of the Müllerian ducts and have acquired secondarily an amazing method of parturition by a direct median passage.

The above names are those which come most readily to mind, though many other investigators have made valuable contributions to our knowledge of the morphology or the marsupial urogenital system.

The Prototypal Marsupial

(Text fig. 1)

In attempting to reconstruct the urogenital system of the ancestral marsupial one is confronted by an intriguing and difficult problem. The evidence of the comparative anatomy and embryology of recent forms requires careful handling, and those best qualified to judge are hardly in accord regarding the prototypal plan on which the marsupial urogenital system was laid down or in the interpretation of the method of evolution which followed.

There is complete agreement, however, that the arrangement of this system in modern marsupials, though showing considerable variation, is based upon a common

plan, and that the modern representatives, far from displaying simple and primitive characters as was at one time thought to be the case, are, in point of fact, a highly specialized group of mammals.

The early promammals were oviparous and from this oviparous stock the Monotremata arose.[1] Later, a group of early mammals achieved viviparity and from this stock both the marsupials (Didelphia) and the so-called placental mammals (Monodelphia) arose. Following on Hill's noteworthy discovery in 1895 of a true allantoic placenta in *Perameles*, most embryologists and morphologists subscribed to the view that those viviparous early mammals had an allantoic placenta, and that all the early marsupials were allantoplacental. Further consideration of this question, however, is outside the scope of the present paper, but it should be observed that the views of Bensley (1903) and McCrady (1938) that the presence of an allantoplacenta in the somewhat specialized *Perameles* may be nothing more than an instance of convergence are worthy of careful consideration.

Whatever opinion may be held on this matter it seems certain that the prototypal marsupial had a rudimentary placenta, formed either by the yolk-sac or allantois, which could not have been very efficient. Foetal life was short in consequence, and parturition took place by way of the two Müllerian ducts.

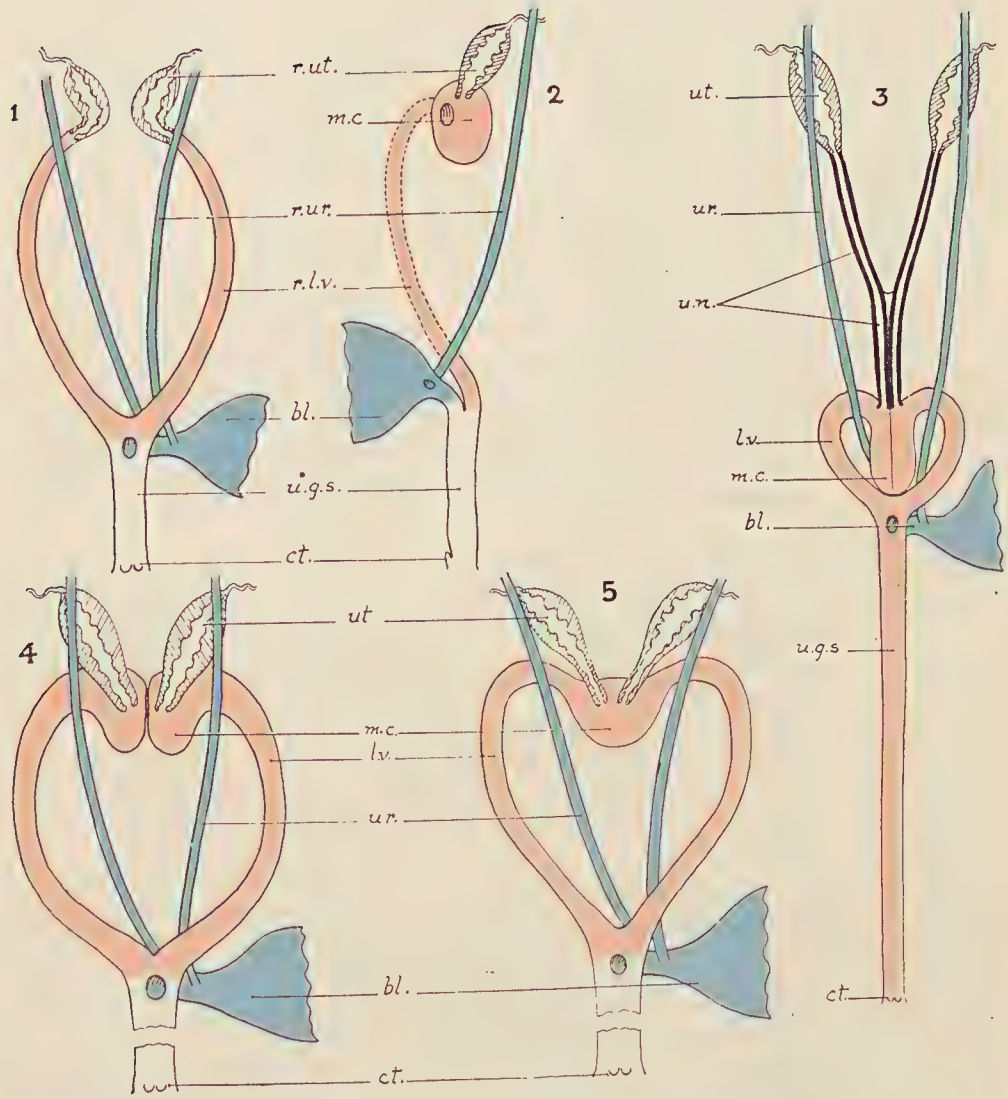
The ancestral marsupial had a fairly simple type of urogenital system. Each Müllerian duct was probably divided into the three constituent parts as we now know them, Fallopian tube, uterus, and vagina. In recent Didelphia and Monodelphia the right and left uteri approach each other medially and the latter group may coalesce. It is reasonable to conclude, therefore, that the convergence of the uteri was present in the ancestral type from which both groups arose, and if that were so it would follow that the early marsupials also had converging uteri. As the post-uterine portions of the two Müllerian ducts in these prototypal marsupials were obliged to pass lateral to the ureters there would be a tendency to develop vaginal kinks which are typical of all recent marsupials. These primitive vaginae probably lacked the vaginal culs-de-sac (text fig. 1) and it was by way of these simple ducts that fertilization and parturition were effected. At their caudal extremities the two vaginae opened together into the urogenital sinus which also received a short urethra from the urinary bladder at the same level. The relation between the ureter and Müllerian duct as seen in recent marsupials was already laid down in the prototypal form, that is to say, the ureters occupied a medial position in relation to the Müllerian ducts which is the reverse of the condition in modern placental mammals.

Didelphidae

(Text figs 2, 4, and 5)

It is generally accepted that the Didelphidae represent among recent marsupials the nearest approach to the prototypal condition. In most members of this family the two Müllerian ducts remain separate throughout life, in itself a primitive character (text fig. 4). The two uterine portions converge to take up a medial position side by side, while the Fallopian tubes and vaginae retain their original lateral positions. Thus the characteristic marsupial kink or elbow is formed in the course of each Müllerian duct at the junction of the uterus and vagina. It is at this point that a median cul-de-sac (text fig. 4, *m.c.*) grows backward from each vagina. These vaginal culs-de-sac vary considerably in different species as regards size and general topography, and rarely, if ever, grow as far back as the

[1] Hubrecht (1908), however, considered that the Monotremata were derived from viviparous mammals which later reverted to the reptilian method, but there would appear to be no sound reasons for this view.



Figs 1-5(1)

FIG. 1.—Prototypal marsupial, dorsal view.

FIG. 2.—Paramedial section of fig. 4 or fig. 5. (In figs 2, 7, 11, 13, 15, and 17 the right lateral vagina is outside the plane of the section but is shown by dotted lines.)

FIG. 3.—*Dasyurus*, dorsal view x about 2.

FIG. 4.—Didelphid, with the culs-de-sac separate (modified, after Hill and Fraser, 1925) x about 3.

FIG. 5.—Didelphid, with the culs-de-sac fused (modified, after Hill and Fraser, 1925) x about 3.

(1) Figs 1-7 and 10-23 are diagrammatic representations of the female urogenital system. Reference letters of all text figures and plates are given on p. 98.

anterior portion of the urogenital sinus, so that there is a definite gap filled with connective tissue of the genital strand which separates the culs-de-sac from the anterior end of the urogenital sinus. In some instances the septum separating the culs-de-sac of right and left sides becomes perforated, or in extreme cases may disappear altogether, thus linking up the vaginal cavities of the two sides (text fig. 5, *m.c.*). This latter condition is almost universal in the more highly specialized marsupials, at least after the first parturition. Hill and Fraser (1925), after a careful examination of the vaginal system in the Didelphidae, came to the conclusion that parturition in that family took place through a ' pseudo-vaginal passage ' forming a direct median passage from the median culs-de-sac to the urogenital sinus. This method of parturition is similar to that described in *Perameles* by Hill (1899) in an earlier paper. A rent appears in the posterior wall of the vaginal cul-de-sac through which the embryos pass. They then make their way caudally through chinks in the connective tissue of the genital cord and find entrance to the urogenital sinus through a temporary break in its anterior wall. These authors expressed the view that, though parturition took place down the simple lateral Müllerian ducts in the primitive marsupials, the usual method of parturition in recent forms is by means of a direct median passage. Further reference to this question of parturition will be made in a later section of the present paper.

Immediately posterior to the uteri the main Müllerian ducts, or lateral vaginae *(l.v.)*, sweep outward like the handles of a vase and in due course converge as they proceed caudally to open together dorso-laterally into the urogenital sinus, while the urinary bladder *(bl.)* is connected with the sinus by means of a short urethra at about the same level but on the ventral side. The urogenital sinus *(u.g.s.)* is a relatively long tube which carried the clitoris on its ventral wall near the posterior extremity. It is important to bear in mind the disposition of the urinary bladder at the anterior end of the long urogenital sinus as this arrangement obtains not only in the Didelphidae but also in most marsupials, with the notable exceptions of the genera *Potoroüs* and *Bettongia* as well as in members of the Peramelidae.

In most marsupials, whether primitive or highly specialized, the bladder is connected with the urogenital sinus by means of a short urethra. There can be little doubt that such was the condition in the prototype of the group and when, as in *Perameles, Potoroüs,* and *Bettongia,* the attachment of the bladder has shifted forward so as to require a long urethral extension from the point of attachment to the urogenital sinus, it is reasonable to conclude that such a condition denotes a departure from the simple and primitive plan.

It should be noted that the urogenital sinus in the Didelphidae, the most primitive of recent marsupials, is long, and the same is true of most members of this group.

Dasyurus and Sarcophilus

(Text fig. 3)

The species examined are the Tasmanian Native Cat, *Dasyurus quoll (= Dasyurus viverrinus)*, and the Tasmanian Devil, *Sarcophilus harrisii.*

On the whole, the female urogenital system of the Australian polyprotodonts is more advanced than that of American forms, particularly as regards the development of the vaginal culs-de-sac. In the American polyprotodonts these are often small and usually there is a definite pseudo-vaginal gap between the culs-de-sac and the urogenital sinus. On the other hand, in Australian forms which have achieved parity the pseudo-vaginal gap hardly exists, as the walls of the culs-de-sac

and the urogenital sinus are in apposition, though their cavities are separated by the intervening walls. In young females the pseudo-vaginal gap is present and gradually becomes reduced as maturity approaches. Hill (1900, *b*) described the female urogenital system of a young *Myrmecobius* in which a pseudo-vaginal gap was shown to exist, but there is no reason to doubt that in the parous adult the condition would be substantially the same as in adult specimens of *Dasyurus* and *Sarcophilus*. All three forms possess a long urogenital sinus and this probably holds good for all true polyprotodonts.

In all essential respects the female urogenital system is built upon the same common plan in *Dasyurus* and *Sarcophilus* and the proportions of the various parts are almost identical (compare, for example, the measurements of *Dasyurus*, No. 23, and *Sarcophilus*, No. 50, given in the table which follows). Text fig. 3 shows the arrangements in *Dasyurus*, and for general purposes this may be taken to represent the condition in *Sarcophilus*. Except where otherwise stated, the following description of the urogenital system is based upon an examination of *Dasyurus*.

The following measurements of the reproductive system of *Dasyurus* and *Sarcophilus* were made in the course of the present investigation:—

	Dasyurus		*Sarcophilus*	
	No. 17	No. 23	No. 27	No. 50
(A) Total length of genital system from the anterior end of the uteri to the posterior end of the urogenital sinus	42 mm.	65 mm.	78 mm.	130 mm.
(B) Antero-posterior length of the lateral vaginae	7 mm.	6 mm.	9 mm.	12 mm.
(C) Antero-posterior distance between anterior end of vaginal culs-de-sac and anterior extremity of urogenital sinus	3·5 mm.	3 mm.	4·5 mm.	6 mm.
(D) Length of urogenital sinus	29 mm.	35 mm.	45 mm.	70 mm.

Uterus

This is divided into an anterior uterine body and a posterior uterine neck. The body is fusiform in shape and is slightly less than one-third of the length of the entire uterus. The neck is a narrow tube which is clearly divided into two portions. The anterior half converges towards its fellow of the other side. When they reach the middle line they turn abruptly in a caudal direction in close contact with each other. Thus the two uterine necks are Y-shaped (text fig. 3, *ut.n.*). Specimens of *Sarcophilus* dissected in the course of the present investigation show substantially the same arrangement. Flynn (1910) figures the urogenital sinus of a female *Sarcophilus* but does not show the posterior half of the uterine necks running side by side as described above. However, in his description he states that 'the two necks approximate and run side by side'. Mackenzie (1919) referring to *Sarcophilus* regards the posterior median portion of the 'Y' as being vaginal rather than uterine. The uterine neck and the vagina are contiguous parts of the Müllerian duct and it might be regarded as an arbitrary matter to define where the one ends and the other begins. The uterine neck is considered to be

that part of the Müllerian duct which lies between the body of the uterus and the vagina, and immediately anterior to the level at which the vaginal cul-de-sac and the lateral vagina arise. Moreover, the posterior end of the uterine neck usually has its opening into the vagina, the *os uteri*, on a papilla which projects into the cavity of the vaginal cul-de-sac. Flynn (1910) refers rather obscurely to the *os uteri* in *Sarcophilus* which would appear to be at posterior extremity of the medial portion of the 'Y'.

It would appear that Mackenzie's view is untenable and that the whole of the Y-shaped portion of the Müllerian ducts should be regarded as uterine.

Vaginal system

The vaginal system is very small relative to the size of the entire urogenital system, as may be seen from text fig. 3 and from the table of measurements given above. In both *Dasyurus* and *Sarcophilus* the distance C (see Table) is only about 9 per cent of D. For purposes of comparison approximate measurements have been taken of the photographs of the Didelphid urogenital system given by Hill and Fraser (1925) and it is found that in the different species C varies from 26 to 57 per cent of D with an average of 37 per cent. It may be said that in all cases where measurements have been recorded of the components of the polyprotodont urogenital system C is less than D and generally C/D is considerably less than half. In diprotodonts, on the other hand, C is almost invariably greater than D.

Vaginal culs-de-sac

In his account of the urogenital system of *Sarcophilus* Mackenzie (1919) states that the septum which separates the right and left culs-de-sac may be absent. It would appear that his observations were based upon dissections alone. Flynn (1910), on the other hand, found that an examination of serial sections through the culs-de-sac of an adult *Sarcophilus* revealed the presence of a well-developed septum. Further investigations are called for and it is hoped to pursue this matter as a sequel to the present work.

Urogenital sinus

As indicated above, the urogenital sinus of polyprotodonts is a relatively large structure, which would appear to refute the contention of Hill (1899, 1900 *b*) that the short urogenital sinus of *Perameles* is a primitive character.

Urinary bladder and urethra

The bladder is attached by means of a short urethra to the anterior end of the urogenital sinus near the level at which the two lateral vaginae open into the sinus. This arrangement is typical of most marsupials, with the exception of *Perameles*, *Potoroüs*, and *Bettongia*.

Perameles

(Text figs 6 and 7)

Since Hill (1899) has given an adequate account of the female urogenital system of *Perameles* there is no reason to traverse the ground already covered by him. For the purposes of the present paper it is sufficient to summarize the outstanding features of the urogenital system of this interesting form only in so far as they are relevant to a discussion on the general morphology of the female urogenital system of the Marsupialia.

Vaginal cul-de-sac *(m.c.)*

This is reminiscent of the condition found in some Didelphids. It is poorly developed and the posterior prolongation found in most marsupials hardly exists

and in consequence the cul-de-sac is separated from the urogenital sinus by a stretch of connective tissue, unequalled in length in any other marsupial. In young animals the right and left chambers are completely separated, but in parous females the median septum disappears (text fig. 6, *m.c.*). However, the vaginal caeca *(v.c.)* which arise from the embryonic Müllerian ducts retain their double structure throughout life. The short cul-de-sac is, on the face of it, a primitive character, though the breaking down of the septum in parous females indicates some specialization. The question whether the small size of the cul-de-sac in *Perameles* may not have been acquired secondarily is discussed below under Parturition.

Vaginal caeca *(v.c.)*

The presence of these large expansions, which lie anterior to the main vaginal complex, is perhaps the most characteristic feature of the female urogenital system of *Perameles*. At first sight there seems to be a single bladder-like expansion about 30 mm. wide and approximately the same length, though its actual dual structure is betrayed to some extent by the bilobed character of the anterior wall. The double nature is clearly revealed, however, if an incision is made in the dorsal or ventral wall, when a thin median septum (text fig. 6, *sept.*) is seen completely separating the right chamber from the left. In the young non-parous female each caecal chamber is connected with the corresponding vaginal cul-de-sac, and although in the parous females, as has been seen, the two culs-de-sac become a single median chamber, the two vaginal caeca retain their integrity throughout life. Now these large anterior expansions of the vaginal system in the Peramelidae are a definite specialization and are only found in one other marsupial, the diprotodont genus *Bettongia*.

Lateral vaginae *(l.v.)*

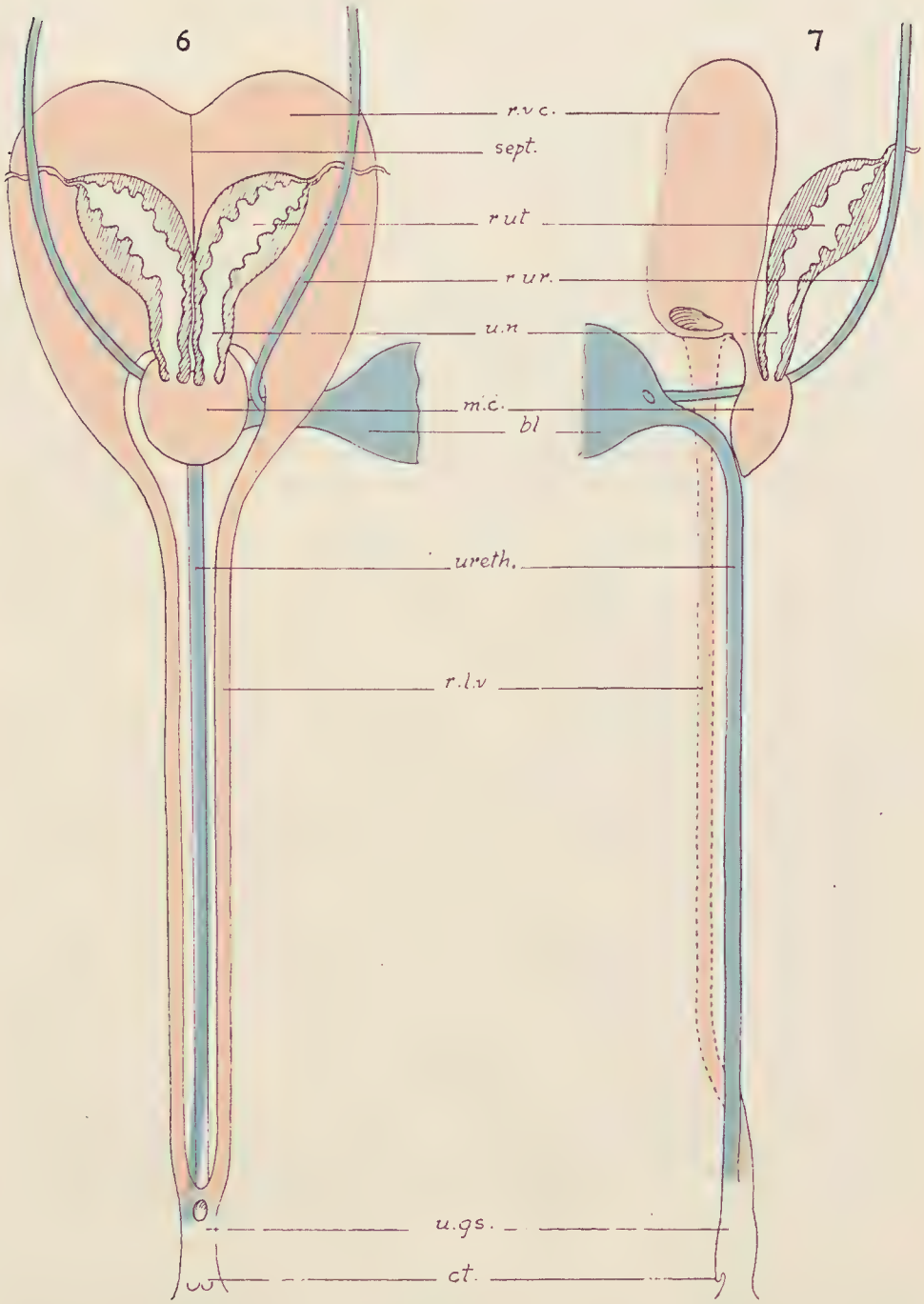
These are long, narrow tubes about 45 mm. in length which arise from the postero-lateral corners of the right and left vaginal caeca. They pass caudally, almost in a straight line, to open into an extremely short urogenital sinus and throughout their entire course they are closely applied to the medially placed urethra and careful dissection is necessary to separate the component parts. It is probable that these long, straight vaginae are more primitive than the vase-handle shaped lateral vaginae so characteristic of the Didelphidae and indeed of most marsupials.

Urinary bladder *(bl.)* **and urethra** *(ureth.)*

The bladder arises about the same level as the short vaginal cul-de-sac and is thus placed much farther forward than in most marsupials. In consequence the urethra is inordinately long (45 mm.) and occupies a medial position between the two lateral vaginae. This extreme anterior position of the bladder and the great length of the urethra are not found elsewhere in the Marsupialia, except in the diprotodont genera *Potoroïs* and *Bettongia*, and this state of affairs must be regarded as being highly specialized. In addition, the Peramelid arrangement is unique in that the long urethra, as it passes caudally to the urogenital sinus, is unaccompanied by any medial portion of the vaginal system.

Urogenital sinus *(u.g.s.)*

This is extremely short, being only about 5 mm. in length, and *Perameles* differs from all other marsupials in this respect. The nearest approach is found in *Potoroïs* where, however, the two lateral vaginae lose their separate identity a considerable distance anterior to the urogenital sinus, whereas in *Perameles* they



Figs 6 and 7

Perameles—Fig. 6, dorsal view, x 2; fig. 7, paramedial section, x 2.

remain separate until they reach the sinus. Hill (1899, 1900 *b*) claims that the short urogenital sinus in this form is primitive, but it is significant that all known primitive marsupials have a relatively long sinus.

Parturition

It was in this genus that Hill (1899) first discovered the amazing method of parturition by means of a ' pseudo-vaginal passage ', which, later, Hill and Fraser (1925) found to be common to most, if not all, Didelphids as well as to many other marsupials. In *Perameles* Hill found that the embryos, instead of passing to the exterior by way of the lateral vaginae, as must undoubtedly have been the case in the earlier stock in which the viviparous method was established, take a short cut through the connective tissue lying between the culs-de-sac and the urogenital sinus. An adventitious channel, unlined by epithelium, is formed and the embryos find their way along this improvised route to the urogenital sinus, thus short-circuiting the devious course followed by the lateral vaginae in most marsupials. Incidentally, it is noted that this median passage is comparable in position to that of the single median vagina of the Monodelphia.

Consideration of the method of parturition by means of this median passage in various members of the Marsupialia justifies the assumption that pseudo-vaginal parturition first appeared in forms in which the culs-de-sac were poorly developed and the pseudo-vaginal gap was, in consequence, relatively long. As this new method gradually established itself its efficiency would be more readily ensured if the culs-de-sac were to extend in a caudal direction thus reducing the size of the gap which had to be traversed by the pioneer embryos in their efforts to reach the urogenital sinus by a direct median route. Ultimately, as has been proved to be the case in the more highly specialized marsupials, the culs-de-sac would reach the urogenital sinus and in some few cases even fuse with it to form a true medial vagina.

From this it might be inferred that *Perameles*, by reason of its having a much longer pseudo-vaginal gap than that of any other marsupial, represents an early phase in the evolution of the pseudo-vaginal apparatus. The weight of evidence, however, appears to be against such a view, as it would be hard to envisage this pseudo-vaginal experiment achieving success if in the first instance the pseudo-vaginal gap had been as great as that found in recent Peramelids. *Perameles* is by no means a primitive marsupial and its urogenital system betrays specialization in at least two important features, viz., the presence of the vaginal caeca and the position of the urinary bladder. It is the view of the present writer that the inordinately long pseudo-vaginal gap in *Perameles*, which at first sight appears to be primitive, is likely to have been acquired secondarily and is, in point of fact, a specialized condition, and it is suggested that the arrangement of this pseudo-vaginal apparatus in *Perameles* has been derived from the Didelphid condition. Thus, the pseudo-vaginal gap in the Peramelids may have been gradually lengthened either by the shortening of the posterior prolongations of the culs-de-sac, or by the shifting and contraction of the urogenital sinus, or by both. There seems to be no reason to doubt that once the pseudo-vaginal method of parturition had been well established in a form in which the pseudo-vaginal gap was of moderate size, adaptation to the gradual lengthening of the pseudo-vaginal gap in the Peramelid stock would have been possible.

Summary

It is considered, therefore, that on the whole the female urogenital system of *Perameles* is not so primitive as Hill claimed. At first sight the short undeveloped

vaginal cul-de-sac and the straight lateral vaginae would be regarded as primitive characteristics and considerable support is given to this view by the presence of the genital cord throughout life. On the other hand, the syndactylous pes in the Peramelids is highly specialized and in at least three characteristics the female urogenital system shows a departure from the primitive condition. These are the development of two large vaginal caeca; the forward position of the urinary bladder and the consequent elongated urethra; and the great length of the pseudo-vaginal gap, which in the writer's opinion has been acquired secondarily.

Potoroüs

(Plates X and XI; Text figs 8, 9, and 12)

So far as can be ascertained the urogenital system of *Potoroüs* has not been described or figured hitherto, though by a confusion in synonomy Owen misled his successors to believe that he had described the urogenital system of a female potoroo when, in fact, he had dealt with a bettong (see Pearson, 1944).

Members of this genus are fast disappearing throughout Australia and for practical purposes it may be said that the Tasmanian variant of *Potoroüs tridactylus* is the only form which can be obtained, and in a few year's time it may be too late to make an anatomical survey of this interesting marsupial. Apart from these considerations the striking condition of the urogenital organs in *Potoroüs* justifies a description in some detail.

The following outstanding features of the urogenital system of *Potoroüs tridactylus* are based upon the dissection of five females.

Fallopian tubes and uteri

The two narrow Fallopian tubes run in a mesial direction and are continuous with their respective uteri which lie in contact with each other in the medial line almost parallel to the longitudinal axis of the body. The uteri are fusiform structures each one narrowing at its posterior end into a well-defined neck.

Anterior vaginal expansion *(a.v.e.)*

Immediately behind the uteri the vaginal apparatus begins as a fairly capacious thin-walled chamber to which it is proposed to apply the term 'anterior vaginal expansion'. This may be regarded as an extension of the anterior portions of the vaginal cul-de-sac and the lateral vagina. By opening up the anterior vaginal expansion it is seen that each uterine neck terminates within this chamber in a well-developed papilla which is perforated at the apex by the *os uteri*. The two papillae lie medially side by side and project from the roof of the chamber into its cavity. The anterior vaginal expansion may be regarded as an incipient caecum such as is found in a much more advanced condition in *Perameles* and *Bettongia* and, as in those genera, probably functions as a receptaculum seminis. Though of double origin it is a single chamber without any sign of a median septum in the adult, and is about 11 mm. long in its antero-posterior axis and 17 mm. wide.

Vaginal cul-de-sac *(m.c.)*

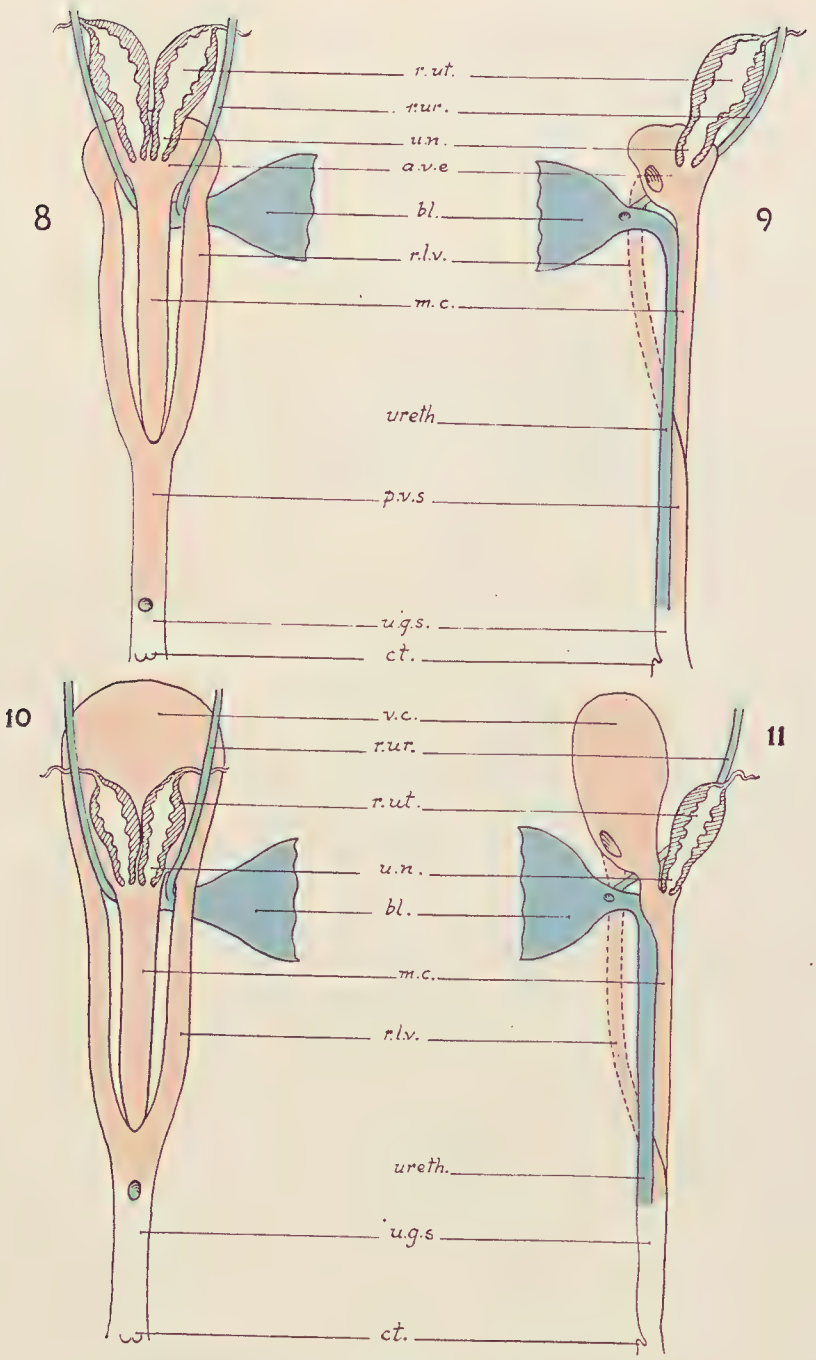
The anterior vaginal expansion is connected medially with the cul-de-sac and laterally with the two lateral vaginae. The cul-de-sac is about 25 mm. long and 4 mm. wide and extends as far back as the posterior vaginal sinus with which it appears to fuse. A close examination, however, shows that the cavities of the two structures remain separate. The original median septum is not present in

the adult though remnants of it may be seen in some specimens. The single chamber ends caudally in two small pockets separated by a median partition which is the last remnant of the original septum. This condition of the posterior region of the cul-de-sac is similar to that described by Lister and Fletcher (1881) in *Hysiprymnus gaimardi* which, in the opinion of the writer (Pearson, 1944), was wrongly identified by them and was, in effect, a potoroo and not a bettong.

Lateral vaginae *(l.v.)*

These are two almost straight tubes 25-30 mm. in length which arise from the postero-lateral corners of the anterior vaginal expansion and run caudally parallel to the cul-de-sac and somewhat closely applied to it. At their caudal extremities they converge and open, not directly into the urogenital sinus as in the case in other marsupials, but into a median dorsal tube which may be designated the *posterior vaginal sinus*. This sinus, which lies dorsal to the urethra, but completely separated from it, runs caudally for a distance of about 17 mm. before opening into the urogenital sinus along with the urethra. So far as is known a well-defined posterior vaginal sinus is not found elsewhere in other marsupials except in *Bettongia* where, however, the length of the sinus is only about one-half of that in *Potoroüs*.

It has been clearly demonstrated (Lister and Fletcher, 1881; Buchanan and Fraser, 1918; Hill and Fraser, 1925; Baxter, 1935) that the lateral vagina of marsupials is not derived from the Müllerian duct alone, but is compounded of the Müllerian duct, which forms the anterior portion, and a much smaller posterior element. In some cases *(Macropus, Trichosurus, Perameles, Dasyurus)* this posterior section is the caudal part of the Wolffian duct which persists and retains its connexion with the urogenital sinus; while in others (Didelphidae, etc.) the non-Müllerian portion of the lateral vagina represents a forward solid epithelial proliferation ('sinus cord') of the urogenital sinus which later acquires a lumen and links up the Müllerian duct with the urogenital sinus. As pointed out by Baxter (1934), this lack of a uniform scheme of vaginal development is by no means confined to the Marsupialia and serves to bring them into line with the Monodelphia where, too, the development of the posterior part of the vagina seems to follow no fixed course. This dual origin of the lateral vagina in marsupials is often shown externally by a constriction marking the junction of the component parts (Lister and Fletcher, 1881), or may reveal itself internally by the posterior section having a smaller lumen or by having a different type of epithelial lining (Hill and Fraser, 1925). In the case of *Potoroüs* there is no such stricture in the course of the lateral vagina and it is conceivable that the posterior vaginal sinus represents the fused posterior portions of the two lateral vaginae which are of non-Müllerian origin. It is interesting to note that a somewhat comparable state of affairs exists in some rodents. In the rat, for example, the urethra and vagina remain separate throughout their entire length. According to Mijsberg the embryonic urogenital sinus divides into two canals, dorsal and ventral. The ventral canal becomes the urethra and the dorsal canal receives the fused vaginae. This suggests the possibility that in the case of *Potoroüs* the posterior vaginal sinus may be part of the embryonic urogenital sinus, and not, as suggested above, the fused posterior non-Müllerian elements of the lateral vaginae. However, in the absence of any precise knowledge regarding the development of the posterior portion of the Müllerian duct and its method of connexion with the urogenital sinus in *Potoroüs* it would be unprofitable to speculate further on the significance and origin of the posterior vaginal sinus.



Figs 8-11

Potoroüs—Fig. 8, dorsal view, x 1½; fig. 9, paramedial section, x 1½.
Bettongia.—Fig. 10, dorsal view, x 1¼; fig. 11, paramedial section, x 1¼.

Urinary bladder *(bl.)* **and urethra** *(ureth.)*

The bladder is attached to the ventral side of the cul-de-sac immediately posterior to the anterior vaginal expansion. A urethra of considerable length (about 40 mm.) runs caudally from this point of attachment, its anterior portion being immediately ventral to the cul-de-sac and closely applied to it, while its posterior section runs ventral to the posterior vaginal sinus as far as the urogenital sinus into which it opens. As stated above in the case of *Perameles*, this extreme anterior position of the bladder is a secondary adaptation.

Urogenital sinus *(u.g.s.)*

This is very short and has a length of about 10 mm. With the exception of the condition in *Perameles*, this is, so far as is known, the shortest urogenital sinus in the Marsupialia.

Parturition

Flynn (1923) has placed on record a definite case, which came under his notice, of parturition through the lateral vagina of *Potoroüs tridactylus*. A unique photograph taken by him has been lodged in the Tasmanian Museum and is here reproduced (pl. X) by courtesy of Professor Flynn. This photograph bears out the conclusions of Lister and Fletcher (1881) in the case of *Hypsiprymnus gaimardi* (probably a wrongly identified specimen of *Potoroüs*, see Pearson, 1944) that parturition in that species took place through the lateral vagina. These have been confirmed by observations made in the course of the present inquiry in which it was found that in two specimens of *Potoroüs tridactylus* which carried small pouch young, there was no connexion between the vaginal cul-de-sac and the posterior vaginal canal. It seems probable, therefore, that in this genus parturition takes place through the lateral vaginae. This is to be regarded not as a primitive characteristic but as a secondary reversion to the prototypal arrangement.

Summary

The urogenital system of *Potoroüs* is noteworthy in the following respects:—

1. Unlike most recent marsupials parturition takes places by way of the lateral vaginae.
2. The anterior portion of the vaginal complex forms a relatively capacious chamber (anterior vaginal expansion) which functions as a receptaculum seminis.
3. The vaginal cul-de-sac has lost all signs of its double origin in parous adults and ends blindly at its caudal end.
4. The lateral vaginae open into the posterior vaginal sinus and not, as is usually the case, directly into the urogenital sinus.
5. The urinary bladder has taken up an anterior position and is connected with the urogenital sinus by means of a long urethra.
6. The urogenital sinus is shorter than in other marsupials, with the single known exception of the Peramelidae.

Bettongia

(Plate XII; Text figs 10, 11, 12, and 13)

The female urogenital system of *Bettongia* has been described and illustrated on two previous occasions, first by Owen (1834) and again by Brass (1880). Both these writers figured the characteristic vaginal caecum which is present in this genus. Unfortunately, Owen confused the issue by changing his identification of

the marsupial which he examined, and it is necessary to review briefly the circumstances which led to the perpetuation of this error. Owen (1834) described and figured the female urogenital organs of the rat-kangaroo *Hypsiprymnus whitei (= Bettongia gaimardi)* and drew attention to the large anterior caecum which arises from the vaginae. Later the same author (Owen, 1841) referred again to this characteristic caecum in exactly the same words but changed his identification of the marsupial to *Hypsiprymnus murinus (= Potoroüs tridactylus)*. In a still later work Owen (1868) repeated this description in the same words and stood by his second identification. Brass (1880) did not clarify the position, as the marsupial dissected by him was given as *Hypsiprymnus* sp. which might have been either a potoroo or a bettong. There can be no question, however, that Brass and Owen examined and described the same form, as the presence of the characteristic caecum in both specimens makes this clear beyond the shadow of a doubt. Lister and Fletcher (1881) stated that the caecum was not present in *Hypsiprymnus gaimardi (= Bettongia gaimardi)* and Hill (1899) and Hill and Fraser (1925) stated that the caecum was present in *Potoroüs*.

From this brief review of the history of the case one would be inclined to conclude that the vaginal caecum was present in *Potoroüs* and absent in *Bettongia*. It has been demonstrated recently (Pearson, 1944) that the reverse is actually the case. Perhaps the confusion has been assisted by the failure of earlier systematists and morphologists to have a clear conception of the nomenclature of the rat kangaroos. The marsupial genus *Potoroüs* was established by Desmarest in 1804, though most biologists until recent years appear to have used, without justification, the name of *Hypsiprymnus* given by Illiger in 1811. The genus *Bettongia* was established by Gray in 1837 to emphasize the important differences between the potoroos and bettongs. Although the bushmen generally lump these two forms under the general name of 'kangaroo rats' or 'rat kangaroos' they can be distinguished with ease.

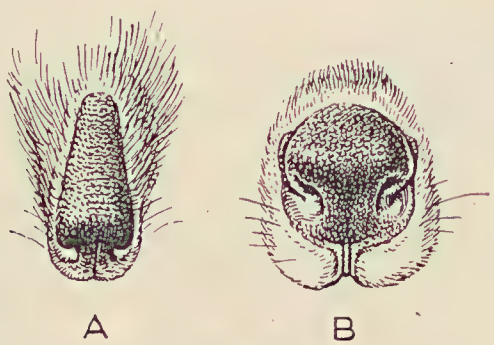


Fig. 12

Rhinaria of (A) *Potoroüs*, (B) *Bettongia* x 1.

There are at least three important external characters which serve as a ready means of distinguishing members of the genus *Bettongia* from those of the genus *Potoroüs*. These are as follows:—

1. The rhinarium is naked and tessellated in both genera but differs markedly in shape. This difference is clearly shown in text fig. 12 in which it is seen that the aboral boundary in *Potoroüs* is much more pointed than in *Bettongia*.

2. In *Potoroüs* the pes is shorter than the head. In *Bettongia* the pes is longer than the head.

3. In *Bettongia* there is a well-developed digital process about 8 mm. long and 1·5 mm. in diameter arising from the median dorsal side of the cloacal opening (pl. XII, *d.p.*). In *Porotoüs* this process is absent, but in the same position there is a tuft of long hairs about 50 mm. long in the adult.

Bettongia, though once abundant, is now almost extinct on the mainland of Australia. It is still fairly common in Tasmania, though not easily procurable. In the circumstances no apology is needed for giving a somewhat detailed description of the urogenital system of the Tasmanian form *(Bettongia cuniculus)*, particularly as certain features of the system are important in a general review such as is given in the present paper.

The following description is based upon an examination of three mature females.

Fallopian tubes and uteri

These are similar in general disposition and appearance to the same parts in *Potoroüs* and call for no special comment. The uterine necks terminate posteriorly in two well-marked papillae which lie side by side and project from the roof of the anterior portion of the median cul-de-sac into its cavity. Each papilla bears a clearly marked *os uteri* at its tip.

Vaginal cul-de-sac *(m.c.)*

In the adult the cul-de-sac shows no signs of its dual origin. It is a long, narrow chamber about 25 mm. long and about 5 mm. wide, which ends blindly at its caudal extremity in close contact with the posterior vaginal sinus. At its anterior extremity a narrow median passage runs forward from the floor of the chamber immediately below the uterine papillae to open into the large single-chambered caecum which lies ventral to the uteri and dorsal to the urinary bladder.

Vaginal caecum *(v.c.)*

The narrow median outlet from the cul-de-sac, already referred to, leads into the vaginal caecum which is a single-chambered sac occupying the same position as the varinal caeca of *Perameles*, that is, between the urinary bladder and the uteri. When fully developed its anterior boundary lies well beyond the uteri and Fallopian tubes. In the adult condition it shows no signs of its dual origin and in this respect differs from the similar structure in *Perameles* which throughout life is divided into two chambers by a thin median septum. As pointed out by Hill (1899) and Hill and Fraser (1925) this large diverticulum is no doubt identical in function with the vaginal caecum of *Perameles* and serves as a receptaculum seminis.(1)

Lateral vaginae *(l.v.)*

These are straight, narrow tubes which arise from the postero-lateral corners of the vaginal caecum, one on each side, and pass caudally parallel to the cul-de-sac and closely applied to it, in much the same manner as in *Potoroüs*. As in that genus the two lateral vaginae open posteriorly into a common dorsal chamber,

(1) These authors referred erroneously to *Potoroüs* which they had confused with *Bettongia* (see Pearson, 1944).

the posterior vaginal sinus, which, however, is much shorter in *Bettongia* being only 9 mm. in length. This sinus lies dorsal to the urethra and both open into a common urogenital sinus.

Urinary bladder *(bl.)* **and urethra** *(ureth.)*

As in the case of *Perameles* and *Potoroüs* the bladder has an anterior position and accordingly the urethra is considerably longer than in most marsupials. It runs caudally for a distance of about 30 mm. ventral to the cul-de-sac and posterior vaginal sinus and opens into the urogenital sinus.

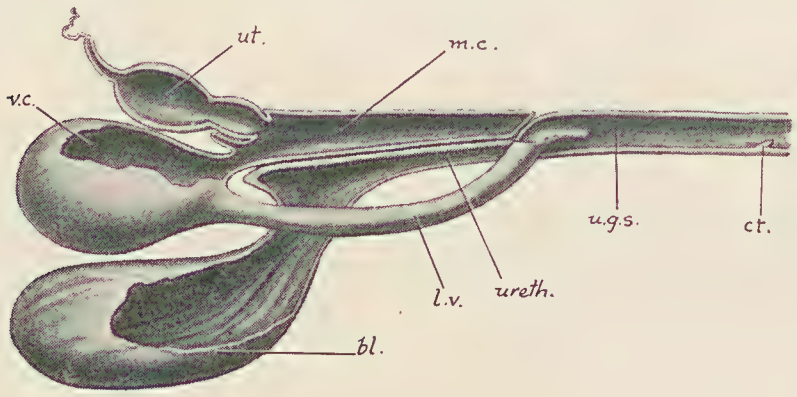


Fig. 13

Paramedial section of the urogenital system in *Bettongia* x 1½.

Urogenital sinus *(u.g.s.)*

This is about 18 mm. long in a mature female and is therefore considerably longer than the urogenital sinus of *Potoroüs*.

Parturition

There is no direct evidence to indicate how parturition takes place in this genus, though Lister and Fletcher (1881), after an examination of *Hypsiprymnus gaimardi (= Bettongia gaimardi)*, concluded that the vaginal cul-de-sac does not acquire a connexion, temporary or otherwise, with the urogenital sinus and that the young pass down the lateral vaginae. But it has been shown (Pearson, 1944) that their identification was wrong and that their specimen was probably a member of the genus *Potoroüs*, since the vaginal caecum was not present. As *Bettongia* possesses a posterior vaginal sinus similar to but much shorter than the comparable structure in *Potoroüs* the reasons given in the case of the latter genus for parturition taking place through the lateral vaginae may also hold good in *Bettongia*.

Summary

The main points in which the female urogenital system of *Bettongia* differs from that in most marsupials may be summarized as follows:—

1. The presence of a large single-chambered vaginal caecum.
2. The extreme anterior attachment of the bladder and the consequent unusual length of the urethra.

3. The presence of a short posterior vaginal sinus comparable to the more highly developed structure in *Potoroüs.*
4. The possibility that, as in *Potoroüs,* parturition may take place by way of the lateral vaginae.

Vombatus (= Phascolomys)

(Text figs 14 and 15)

The following notes are based upon an examination of several specimens of the Tasmanian wombat, *Vombatus (= Phascolomys) ursinus tasmaniensis.*

Uteri

The two uteri lie with their posterior two-thirds in contact along the median line. In the fully developed condition each uterine body is almost globular, the antero-posterior diameter being about 21 mm. and the transverse diameter about 17 mm. The neck of the uterus is much narrower and most of it is hidden by the walls of the vaginal culs-de-sac. The posterior portion of each neck projects a considerable distance into the cavity of the corresponding cul-de-sac and is comparatively large so that it almost fills the entire anterior portion of the cul-de-sac. This portion of the neck is noteworthy in having an irregular papillose surface. The *os uteri* lies slightly anterior to the free tip.

Vaginal culs-de-sac

These are robust structures and their cavities are completely separated from one another by a thick septum which, so far as is known, remains intact throughout life. The posterior extremities of the culs-de-sac are in close contact with the converging posterior ends of the lateral vaginae, but do not open into them. The antero-posterior length of the culs-de-sac is about 32 mm.

Lateral vaginae

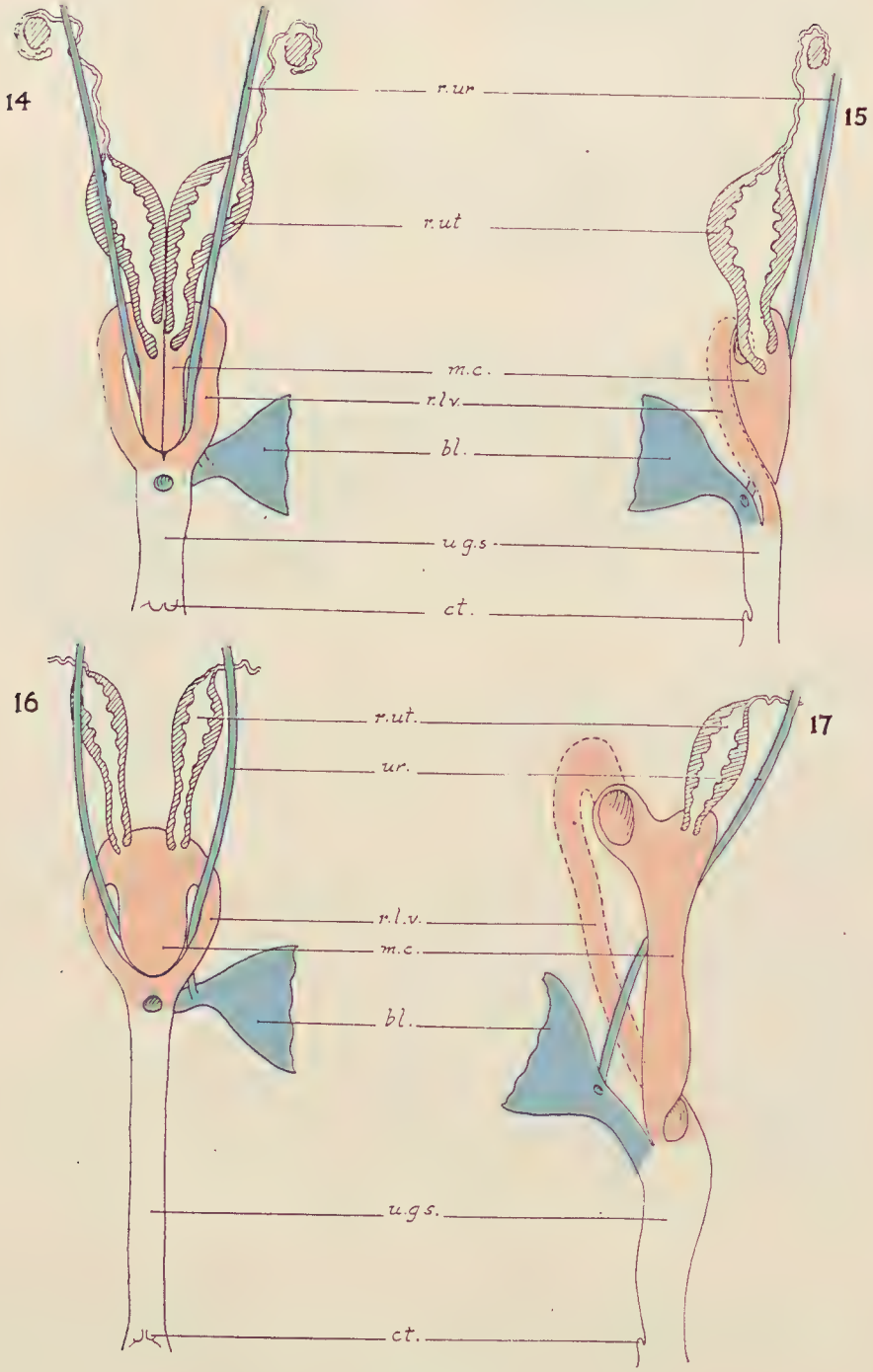
These lie closely applied to the sides of the vaginal culs-de-sac. Externally the two lateral vaginae appear to converge into a common median portion which lies immediately caudal to the culs-de-sac. Dissection reveals, however, that this common median portion is separated internally for a short distance by a median septum which seems to be variable in size in different specimens and which terminates in front of the urethral opening.

Bladder and urogenital sinus

The bladder is connected with a short urethra which opens into the urogenital sinus about 8 mm. behind the caudal extremity of the culs-de-sac. The urogenital sinus passes caudally for a distance of about 24 mm. There is a well-developed clitoris situated ventrally at the posterior end of the sinus. Internally the entire length of the sinus is marked by a series of strong longitudinal muscle bands.

Parturition

According to Hill and Fraser (1925) parturition takes place in the koala by means of a short pseudo-vaginal passage and it is not improbable that the same holds good in the wombat. The latter has a type of cul-de-sac which is reminiscent of the condition found in some Australian polyprotodonts and in this respect differ from other diprotodonts. In polyprotodonts, however, the length of C (median vaginal length) is less than the length of D (length of the urogenital sinus), whereas in the wombat C (32 mm.) is greater than D (24 mm.).



Figs 14-17

Vombatus—Fig. 14, dorsal view, x $\frac{3}{8}$; fig. 15, paramedial section, x $\frac{3}{8}$.
Trichosurus—Fig. 16, dorsal view, x $\frac{3}{4}$; fig. 17, *Wallabia*, paramedial section (after Brass, 1880).

Brass (1880) figured the urogenital system of a wombat. His drawing makes it clear that his specimen was an immature female as the vaginal culs-de-sac are shown as ending freely in front of the posterior junction of the two lateral vaginae. Unfortunately Wiedersheim in his *Vergleichende Anatomie der Wirbeltiere* took over Brass' illustration and this has since been repeated in the English edition of the same work and in all the editions of a well-known English text-book on zoology. The consequence has been that several generations of zoologists have been given an erroneous impression of the condition of the culs-de-sac in *Vombatus*.

The above account of the female urogenital system of the wombat also applies substantially to the koala, *Phascolarctos cinereus* (see Forbes, 1881). However, in the koala the relative proportions of the vaginal system and the urogenital sinus differ from those of the wombat. According to Forbes the proportions in the koala are as follows:—

Total antero-posterior length of vagina	16 mm.
Length of cul-de-sac	11 mm.
Length of the urogenital sinus	32 mm.

So that, unlike the wombat, D is greater than C in the koala.

Trichosurus

(Text fig. 16)

The condition of the female urogenital system in *Trichosurus* is probably typical of the diprotodont family Phalangeridae as a whole.

The right and left uterine necks are not in contact in the middle line but are separated at their posterior ends by a distance of about 6 mm. and the two ora uterorum, in consequence, are situated laterally.

The two vaginal culs-de-sac form a single chamber in parous females and in such specimens only slight traces of the septum are to be found on the dorsal and ventral walls of the chamber. As Hill (1900, *c*) has pointed out, the septum is intact prior to the first parturition. Here again, as in the case of the wombat, Brass (1880) figured an immature specimen. His figure shows a well-defined septum separating the two culs-de-sac thus giving the impression that this is the typical condition in *Trichosurus*. Unfortunately, as in the case of the wombat, this figure has found its way into some of the text-books. This single median chamber has an antero-posterior length of about 25 mm. in a fully grown female. Its posterior wall is in close apposition to the anterior wall of the urogenital sinus, or more correctly, to that short median chamber which lies immediately anterior to the true urogenital sinus and which is formed by the confluence of the two lateral vaginae. It should be emphasized, however, that the vaginal cul-de-sac ends blindly and does not open into the urogenital sinus.

The urogenital sinus has a total length of about 60 mm. in a fully-grown specimen, so that, unlike many diprotodonts, D is greater than C. This is also true of the ring-tailed phalanger, *Pseudocheirus*, and the flying phalanger, *Petaurus breviceps*, the honey phalanger, *Tarsipes spencerae*, and the pygmy glider, *Acrobates pygmaeus*. It is not unlikely, therefore, that the possession of a long urogenital sinus is characteristic of all the Phalangeridae.

Hill (1900, *c*) has shown that parturition takes place in this genus by means of a pseudo-vaginal passage.

Macropodinae

(Text fig. 17)

In this sub-family the vaginal culs-de-sac reach their highest development and, with perhaps a single exception, can no longer be regarded as blind median outgrowths of the vaginal system, except during their earlier stages. For the first time they become a true functional vagina, that is to say, they lose their median septum in the mature condition and sooner or later this single median chamber acquires a permanent connexion with the urogenital sinus.(1)

There are three conditions:—

1. There appears to be only one exception to the above general rule, viz., *Macropus major*, in which the median cul-de-sac never acquires a permanent connexion with the urogenital sinus at any stage, and parturition probably takes places through a short pseudo-vaginal passage as in such forms as *Trichosurus*.
2. The most common condition is that in which a permanent through passage is established at the time of the first parturition. Such is probably the case in *Thylogale billardierii* (Desmarest) where a permanent connexion between the median vagina and the urogenital sinus exists in parous females. This was first recorded by Luca in 1867 and the presence of this connexion in a female carrying a pouch-young has been confirmed in the course of the present investigation.
3. In rare instances the median vagina establishes a permanent connexion with the urogenital sinus in non-parous females. This condition, which may be regarded as the highest development in the vaginal system of the Marsupialia, has been recorded by Brass (1880) in Bennett's wallaby, *Wallabia rufogrisea frutica* (Ogilby) (text fig. 17), and by Lister and Fletcher (1881) in *Wallabia bicolor* Desmarest *(= Halmaturus ualabatus)*.

General Summary

Though the female urogenital system of all marsupials is based upon a common plan it is clear that there is considerable disparity between the relatively simple design of the vaginal apparatus in the American polyprotodonts at one end of the scale and the more complex condition found in the highly specialized Australian diprotodonts at the other end. This is mainly due to the elaboration of the vaginal culs-de-sac and their adaption to the novel mode of parturition by way of a median passage. The differences are also caused in some measure by such complications as the development of vaginal caeca in *Perameles* and *Bettongia*, the forward shifting of the urinary bladder and the consequent lengthening of the urethra in the Peramelidae and the Potoroinae, and by the variability in the length of the urogenital sinus. These matters are treated in some detail in the present paper and the review thus presented emphasizes the unimportant role played by the lateral vaginae in recent Marsupialia. Deposed from their original important status as parturient ducts they now serve only to ensure that the

(1) Many authors use the term 'median vagina' even in those cases in which the median portion of the vaginal system ends blindly and never acquires a connexion with the urogenital sinus. In such instances the more appropriate, if rather clumsy, term 'cul-de-sac' is used in the present paper. It seems more correct to limit the term 'median vagina' to those cases in which there is a direct connexion with the urogenital sinus.

spermatozoa reach the uteri and even this service is probably no longer necessary in those Macropodinae in which a true permanent median vagina exists. The process of parturition has now been transferred to a new and more direct route by way of those secondary outgrowths of the Müllerian ducts, the vaginal culs-de-sac. The present paper attempts to trace the gradual elaboration of this new vaginal apparatus from the primitive arrangement of the culs-de-sac in some Didelphidae to the establishment in the highest marsupials of a complete median vagina lying between the ureters as in the Monodelphia. Except in the specialized Potoroinae, where there is a secondary return to the primitive condition, parturition probably takes place by means of a median passage in all recent marsupials. This method started as an amazing makeshift contrivance (pseudo-vaginal passage) which must have been attended by considerable risk, and has culminated in the establishment of a true median vagina in some of the Macropodinae.

In the following summary of the points dealt with in the present paper attention is focussed mainly upon the elaboration of the median vaginal apparatus, though other characteristics of the urogenital system of the Marsupialia are also given. In this summary the marsupials which are dealt with in the present paper are arranged in a logical sequence according to the degree of elaboration of the median vaginal apparatus, starting with the hypothetical prototypal marsupial and culminating in the specialized Macropodinae. The Peramelidae and Potoroinae *(Potoroüs* and *Bettongia)* cannot be fitted into such a series and consequently they have been placed by themselves at the end of the series, but not as part of it.

Prototypal marsupial (Text fig. 1)

No vaginal culs-de-sac.
Parturition by way of the primitive Müllerian ducts.

Didelphidae (Text figs 2, 4, and 5)

Vaginal culs-de-sac small and never reach the urogenital sinus. Septum sometimes present throughout life but may break down in parous females.
Parturition by moderately long pseudo-vaginal passage.
Urinary bladder attached by short urethra to anterior end of urogenital sinus.
Vaginal antero-posterior length shorter than urogenital sinus.

Dasyuridae (Text fig. 3)

Vaginal culs-de-sac reach the urogenital sinus but do not open into it. Septum usually present throughout life.
Parturition by very short pseudo-vaginal passage.
Urinary bladder attached by short urethra to anterior end of urogenital sinus.
Vaginal antero-posterior length shorter than urogenital sinus.

Vombatidae (Text figs 14 and 15)

Vaginal culs-de-sac reach urogenital sinus but do not open into it. Septum present throughout life.
Parturition by very short pseudo-vaginal passage.
Urinary bladder attached by short urethra to anterior end of urogenital sinus.
Vaginal antero-posterior length greater than length of urogenital sinus.

Phalangeridae (Text fig. 16)

Vaginal culs-de-sac reach urogenital sinus but do not open into it. Septum usually not present in parous females.

Parturition by very short pseudo-vaginal passage.
Urinary bladder attached by short urethra to anterior end of urogenital sinus.
Vaginal antero-posterior length less than that of urogenital sinus.

Macropodinae (Text fig. 17)

With exception of *Macropus major*, where the vaginal relationship to the urogenital sinus is similar to that in the Phalangerinae, a true median vagina is formed. The two culs-de-sac fuse into a single chamber, which acquires a permanent connexion with the urogenital sinus.

Parturition takes place through the median vagina.
Urinary bladder attached by short urethra to anterior end of urogenital sinus.
Vaginal antero-posterior length greater than that of urogenital sinus.

Peramelidae (Text figs 6 and 7)

Vaginal culs-de-sac feebly developed. No larger than in some primitive Didelphidae. Septum breaks down in parous females. Right and left vaginal caeca.

Parturition by extremely long pseudo-vaginal passage.

Urinary bladder fixed at considerable distance anterior to urogenital sinus with which it is connected by a long urethra.

Very long lateral vaginae.

Very short urogenital sinus.

Potoroinae (Plates X-XII, Text figs 8-13)

Vaginal culs-de-sac reach posterior vaginal sinus but do not open into it. (This sinus opens into the urogenital sinus.) Septum not present in parous females. Vaginal caecum may be present. *(Bettongia.)*

Parturition by way of lateral vaginae.

Urinary bladder attached by long urethra a considerable distance anterior to the urogenital sinus.

Vaginal antero-posterior length greater than that of urogenital sinus.

ADDENDUM

Relative positions of the ureters and genital ducts

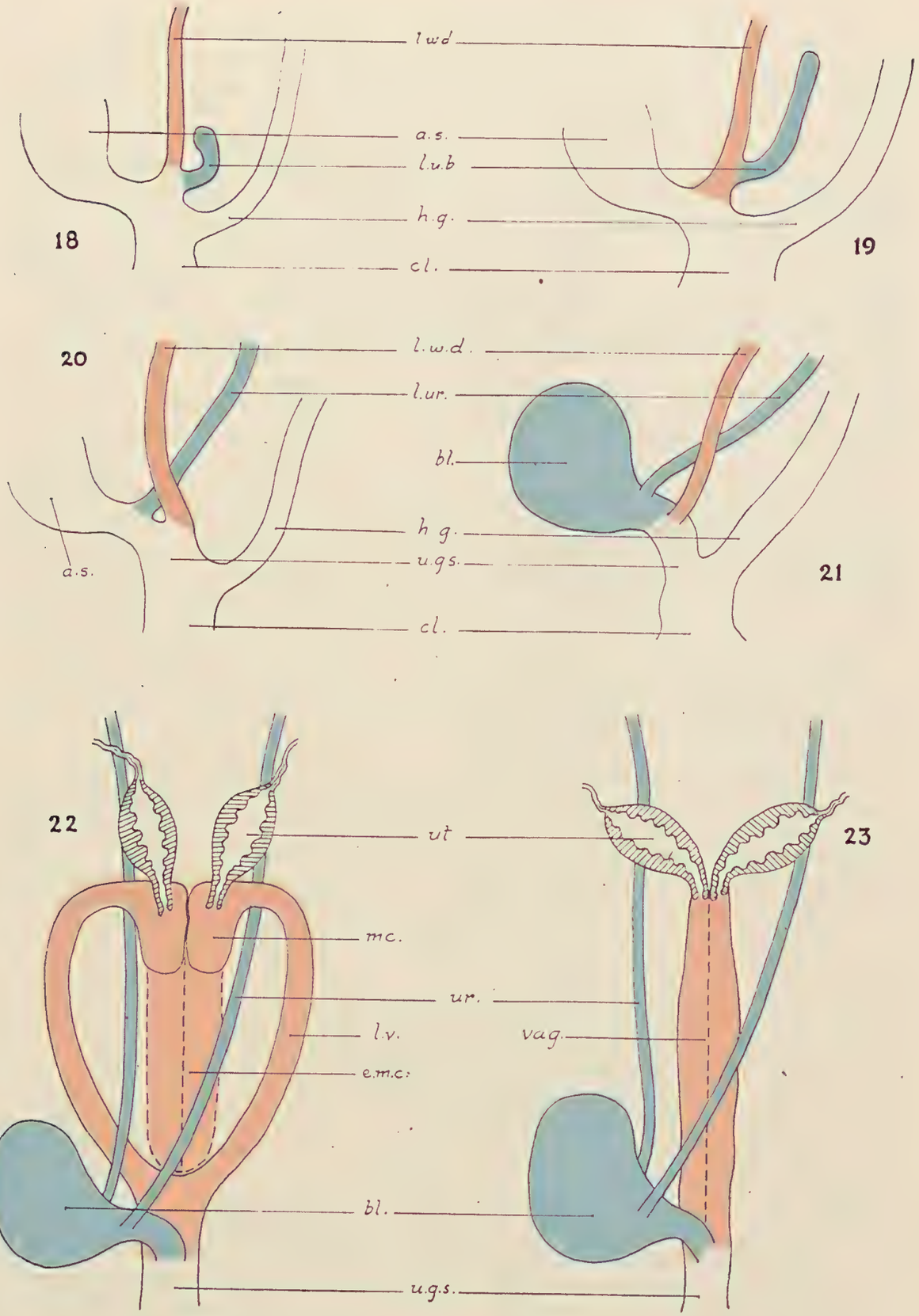
(Text figs 18-23)

Wood Jones (1943, p. 75) has reduced the diagnostic characters of the Marsupialia (Didelphia) to a simple definition as follows:—'A marsupial is a mammal whose kidney ducts lie mesial to its oviducts', but it would be more correct and complete to define a marsupial as a mammal in which the kidney ducts lie mesial to the genital ducts in *both* sexes. On the other hand, the Monodelphia could be defined as mammals in which the kidney ducts lie lateral to the genital ducts in both sexes. It is proposed to examine further this basic difference between the Didelphia and Monodelphia as it is a matter which cannot be ignored in any general discussion on the female urogenital system of the Marsupialia. For this purpose it will be necessary to follow briefly the development of three embryonic ducts, viz., the Wolffian duct (mesonephric duct), the ureter (metanephric duct), and the Müllerian duct.

Phylogenetically the Wolffian and Müllerian ducts probably arose by the longitudinal splitting of the archinephric duct. In ontogeny the Müllerian duct arises lateral to the Wolffian duct at each side of the body, but in the development of all known vertebrates and particularly in the Mammalia, there is a considerable time-lag in the first appearance of the Müllerian duct. For example, in the marsupial *Trichosurus* (Buchanan and Fraser, 1918) the Wolffian duct actually reaches the cloaca and opens into it before the *anlage* of the Müllerian duct can be detected between the 8th and 9th spinal ganglia of the embryo. Clearly the reason for this lag is, as Graham Kerr has pointed out, that the Wolffian duct, as the duct of the mesonephros, is called upon to function at a much earlier stage than the Müllerian duct, which, as a reproductive duct, will not be required until the organism attains maturity. In marsupials the mesonephros is functional before birth. The Müllerian duct, on the other hand, is not required for at least several months after birth and, in point of fact, does not open into the urogenital sinus until some time after birth. This change in the ontogenetic tempo of structures, which phylogenetically were contemporary, is in accord with the revised interpretation of the Recapitulation Theory which is now held by embryologists.

In *Trichosurus* Buchanan and Fraser (1918) have shown that each Wolffian duct opens into the cloaca at the 7 mm. G.L. stage. Almost immediately afterwards the ureteric bud arises from the dorsal side of the Wolffian duct near its posterior end (text fig. 18). The ureteric bud shifts mesially so that ultimately the ureter lies mesial to the Wolffian duct (text figs 20, 21), a characteristic which is common to all didelphians. In the Monodelphia, on the other hand, the ureteric bud, after arising from the dorsal side of the Wolffian duct, shifts laterally so that the ureters take up a position lateral to the Wolffian ducts. Both these divergent conditions are departures from the primitive arrangement found in the Sauropsida and Monotremata where each ureteric bud retains its neutral position on the dorsal side of the Wolffian duct.

The anterior extremity of each Müllerian duct *(ostium abdominale)* is the first part to appear at about the 7·75 mm. G.L. stage in *Trichosurus* (Buchanan and Fraser, 1918) and grows backward in close contact with the Wolffian duct, first lateral to it, then ventral, and finally, at the caudal end, mesial to it. Thus each Müllerian duct forms a loose spiral around the corresponding Wolffian duct. In *Didelphis*, according to Baxter (1935), the growing tip of the Müllerian duct is in such intimate contact with the Wolffian duct that no mesenchyme structures intervene between the two ducts. Baxter says 'the Wolffian duct is used as a guide rail by the growing Müllerian duct but does not contribute in any way to the formation of the latter which increases in length purely as the result of the multplication of its own cells'. This interpretation of Baxter's is open to question. Phylogenetically the two ducts are very intimately associated, whether we accept the view that the archinephric duct splits to form both the Wolffian and Müllerian ducts, or whether the Wolffian duct may be regarded merely as a later phase of the archinephric duct which by cell proliferation gives rise to the Müllerian duct. In support of this latter contention it is interesting to note that in some Elasmobranchs the Wolffian duct actually contributes cell units towards the formation of the Müllerian duct. In the higher vertebrates the considerable time-lag in the formation of the Müllerian duct and the manner in which this duct follows faithfully the course already taken by the Wolffian duct is consistent with the hypothesis that some of the cells of the Wolffian duct control the development of the Müllerian duct whether as organizers, as the term is generally understood, or in some other way, even if they do not contribute material cells towards the building of the new duct. It is doubtful, therefore, whether Baxter's pronouncement that the Wolffian



Figs 18-23

FIGS 18-21.—Four stages in the development of the left ureter in *Trichosurus* showing the origin of the left ureteric bud from the left Wolffian duct, and the mesial shifting of the left ureter (after Buchanan and Fraser, 1918).

FIGS 22-23.—Comparison of the Didelphia (fig. 22) and Monodelphia (fig. 23) to show the relations of the vaginae and ureters.

duct does not contribute *in any way* to the formation of the Müllerian duct is in accord with the view that in ontogeny certain cells may organize other groups of cells and determine their destiny.

By the time that the Müllerian duct reaches the level of the urogenital sinus on the medial side of the Wolffian duct the ureter is already well established in *Trichosurus* and the metanephros which develops from the cephalic end of the ureter, is functioning. The mesonephros, on the other hand, is degenerating at this stage, and in the female the anterior portion of the Wolffian duct is fast disappearing, though the caudal portion may still retain for a time its connexion with the urogenital sinus.

In passing, it may be observed that though the phylogenetic sequence of development is (1) Wolffian duct and Müllerian duct, and (3) ureter, the ontogenetic sequence is (1) Wolffian duct, (2) ureter, and (3) Müllerian duct. It is also of interest to note that in the Amniota, which alone of the vertebrates possess a functional metanephros, the ureter appears in ontogeny before the metanephros, although in phylogeny it would be reasonable to expect that the segmental tubules of the metanephros would appear in advance of their duct.

It will be seen from the above brief summary of the development of the three ducts that (1) the ureter arises as an outgrowth from the Wolffian duct and their position in relation to each other is finally determined before the Müllerian duct reaches the urogenital sinus, i.e., the ureter is mesial to the Wolffian duct in Didelphia and lateral to it in the Monodelphia, and (2) since the Müllerian duct follows the course of the Wolffian duct and is in the closest association with it, it is clear that the position of both these ducts in relation to the ureter is the same. The Wolffian duct, therefore, may be regarded as the datum which must form the starting point in any discussion dealing with the relative position of the ureters and Müllerian ducts.

Therefore if each ureter is mesial to the Wolffian duct in the Didelphia the ureter will also be mesial to the Müllerian duct. As the Woffian duct becomes the genital duct of the male and the Müllerian duct is the genital duct of the female, it follows that in the Didelphia the ureters are mesial to the genital ducts in both sexes. Conversely in the Monodelphia the ureters are lateral to the genital ducts in both sexes. This would appear to be a more satisfactory and complete definition than the one given by Wood Jones. (Text figs 22 and 23 show the relative positions of the ureters and female genital ducts in the Didelphia and Monodelphia.)

This fundamental difference between the Marsupialia (Didelphia) and the higher mammals (Monodelphia) is due, as we have seen, to the shifting of the ureteric bud mesially in the first group and laterally in the second. Comparative anatomy and embryology provide no clue to the reason why this important clear-cut distinction should have arisen, any more than they provide an explanation for the persistence of the right aortic arch in birds and the left aortic arch in mammals. But whatever the cause of these cardinal modifications in the position of the ureters, the phylogenetic stage at which they were established marks an important point of divergence of primitive didelphian and monodelphian stocks, both of which were derived from a common mammalian ancestor in which, presumably, the ureteric buds arose from a neutral position on the dorsal sides of the Wolffian duct in the true sauropsidan manner.

In discussing this fundamental difference in the topography of the ureters and Müllerian ducts in the Monodelphia and Didelphia Wood Jones (1943, p. 75) writes ' In the higher mammals there is a stage in which it might be said that it is touch and go which side the ureters will pass the oviducts, and in the end they go to the lateral side of them. In the marsupials they pass to the medial

side', and again 'But for some reason, for which at present there is no explanation, the kidney ducts, from occupying a neutral dorsal position in the Ornithodelphia, passed to opposite sides of the female genital ducts in the diverging phyla of the Monodelphia and the Didelphia. By passing to the medial sides of the female ducts in the Didelphia, the kidney ducts prohibit that caudal meeting that produces the pregnancy chamber or chambers, with a median vaginal outlet, that typifies all members of the Monodelphia' (*l.c.*, p. 87).

These statements interpret somewhat loosely and unsatisfactorily the facts of the case as outlined above and might convey two wrong impressions, first, that the 'oviducts' take up their position prior to the establishment of the ureters, whereas the reverse is actually the case; and, secondly, that because of their position mesial to the female ducts the ureters prohibit the formation of a medially placed vagina. The position of the ureters does not in itself constitute a physical obstacle to the passing of the two Müllerian ducts between the ureters. The essential point is that as the Müllerian ducts grow caudally they are bound by their phylogenetic relationship to the Wolffian ducts to follow the course already taken by these ducts, and so they pass lateral to the ureters. But in spite of this disability the marsupials have evolved, secondarily, a direct median route connecting the uteri with the urogenital sinus, and this route, it should be marked, passes mesial to the ureters and follows precisely the same path as the one traversed by the vagina of the Monodelphia (see text figs 22 and 23).

The evolution of this secondary vaginal apparatus, which provides a method of parturition by means of a median passage for nearly all recent marsupials, is perhaps the most outstanding feature of the female urogenital system of the group. It involves the progressive development of the two vaginal culs-de-sac, by means of which a precarious and makeshift method of parturition through the pseudo-vaginal passage was established, a method which culminated in an efficient and permanent median vagina in some of the more specialized marsupials. This development of an entirely new mode of parturition was brought about through the inadequacy of the two Müllerian ducts for this purpose. Once the change from oviparity to viviparity had been effected the new functions which the Müllerian ducts were called upon to perform would be carried out more efficiently if the two ducts were to coalesce and thus provide a tube of larger calibre. In both Monodelphia and Didelphia the experiment was made, though in different ways. In the former the two vaginae lay mesial to the ureters and were thus able to coalesce. In the Didelphia, on the other hand, a median vagina has been established secondarily in the more specialized forms. Wood Jones (1943) has dealt with this at some length, but his interpretation of the method by which this secondary median vagina has been achieved will hardly be acceptable to most biologists.

Based upon the observations of Lister and Fletcher (1881), Fletcher (1882, etc.), Hill and Fraser (1925) and others, the stages in the probable evolutionary sequence of this secondary vaginal apparatus have been given above. This series traverses the development of this system from the incipient pseudo-vaginal passage in the Didelphidae, through the more advanced condition found in the Australian polyprotodonts and culminating in the complete establishment of a true median vagina, having a continuous epithelial lining, in some of the Macropodidae. This ultimate structure, it should be emphasized once again, follows precisely the same course, mesial to the ureters, that is taken by the vagina in the Monodelphia, thus adding yet another instance to the long list of homoplastic structures known to occur in the Marsupialia.

If we cared to indulge in a little harmless speculation as to the future course of the evolution of the vaginal system in this interesting group we might envisage

the newly gained median vagina of the Macropodinae firmly establishing itself and the almost useless lateral vaginae gradually degenerating into a pair of tubes having their cavities partially or completely occluded, until utimately the highest types of marsupials would possess a single vagina situated between the ureters and differing in no respect from the Monodelphian type except in its phylogenetic and ontogenetic history. Perhaps this would be no more amazing than many other examples of convergence that can be called to mind, especially within the Marsupialia, a group pre-eminent in its many examples of homoplasy.

References

Baxter, J. S., 1935.—Development of the female genital tract in the American opossum. *Carn. Inst. Wash. Contr. to Embryology*, XXV, No. 145, pp. 17-35.

Bensley, B. A., 1903.—On the Evolution of Australian Marsupialia with remarks on the relationships of the marsupials in general. *Trans. Linn. Soc. Lond.* (2), vol. IX, part 3, pp. 83-217.

Brass, A., 1880.—Beiträge zur Kenntniss des weiblichen Urogenital-systems der Marsupialen. *Inaug. Diss.*, Leipzig.

Buchanan, G., and Fraser, E. A., 1918.—The development of the Urogenital System in the Marsupialia, with special reference to Trichosurus vulpecula. Part I, *Journ. of Anatomy*, vol. 53, pp. 35-95.

Fletcher, J. J., 1882.—On the existence after parturition of a direct communication between the Median Vaginal Cul-de-sac, so-called, and the Urogenital Canal, in certain species of Kangaroos. *Proc. Linn. Soc. N.S.W.*, vol. VI, pp, 796-811.

———, 1883.—On some points in the anatomy of the Urogenital Organs in females of certain species of Kangaroos. Part I, *Proc. Linn. Soc. N.S.W.*, vol. VII, pp. 640-659.

———, 1884.—On some points in the anatomy of the Urogenital Organs in females of certain species of Kangaroos. Part II, *Proc. Linn. Soc. N.S.W.*, vol. VIII, pp. 6-11.

Flynn, T. T., 1910.—Contributions to a knowledge of the anatomy and development of the Marsupialia. No. 1: The genitalia of Sarcophilus satanicus (♀). *Proc. Linn. Soc. N.S.W.*, vol. 35, pp. 873-886.

———, 1923.—Remarks on the method of Parturition in *Potoroüs tridactylus*. *Proc. Linn. Soc. N.S.W.*, vol. XLVII, part 5, p. xxviii.

Forbes, W. A., 1881.—On some points in the Anatomy of the Koala (Phascolarctos cinereus). *Proc. Zool. Soc. Lond.*, pp. 180-195.

Hill, J. P., 1899.—On the female Urogenital Organs of Perameles, with an account of the phenomena of Parturition. *Proc. Linn. Soc. N.S.W.*, vol. XXIV, pp. 42-82.

———, 1900, *a*.—On the foetal membranes, placentation, and parturition of the Native Cat (Dasyurus viverrinus). *Anat. Anz.*, Bd. 18, pp. 364-373.

———, 1900, *b*.—On the female Urogenital Organs of Myrmecobius fasciatus. *Proc. Linn. Soc. N.S.W.*, vol. XXV, pp. 519-522.

———, 1900, *c*.—On the existence at parturition of a pseudo-vaginal passage in Trichosurus vulpecula. *Ibid.*, pp. 526-531.

Hill, J. P., and Fraser, E. A., 1925.—Some observations in the female Urogenital Organs of the Didelphyidae. *Proc. Zool. Soc. Lond.*, 1925, pp. 189-219.

Hubrecht, A. A. W., 1909.—Early ontogenetic Phenomena in Mammals and their bearing on our interpretation of the Phylogeny of the Vertebrates. *Quart. Journ. Micr. Sci.*, vol. 53, pp. 1-181.

Jones, F. Wood, 1943.—*Habit and Heritage*, Kegan Paul, Trench, Trubner & Co., London.

Lister, J. J., and Fletcher, J. J., 1881.—On the condition of the median portion of the Vaginal Apparatus in the Macropodidae. *Proc. Zool. Soc. Lond.*, 1881, pp. 976-996.

McCrady, E., 1938.—*The Embryology of the Opossum*. Wistar Inst. Anat. and Biol. Philadelphia. 226 pp.

Owen, R., 1834.—On the generation of the Marsupial Animals with a description of the impregnated uterus of the Kangaroo. *Phil. Trans. Roy. Soc. Lond.*, 1834, part I, pp. 333-364.

———, 1841.—*Marsupialia*. Todd's Cyclopaedia of Anatomy and Physiology, pp. 1-74.

———, 1868.—*Comparative Anatomy and Physiology of Vertebrates*, vol. III, pp. 680-685. Longman, Green, & Co., London.

Pearson, J., 1944.—The Vaginal Complex of the Rat-Kangaroos. *Austr. Journ. Sci.*, vol. VII, No. 3, pp. 80-83.

MacKenzie, W. C., 1919.—*The genito-urinary system in Monotremes and Marsupials*. Jenkin, Buxton, & Co., Melbourne.

Reference letters used in Text Figures and Plates

a.s.—allantoic stalk
a.v.e.—anterior vaginal expansion
bl.—urinary bladder
cl.—cloaca
ct.—clitoris
d.p.—digital process
e.m.c.—backward extension of cul-de-sac
h.g.—hind-gut
l.u.b.—left ureteric bud
l.ur.—left ureter
l.v.—lateral vagina
l.w.d.—left Wolffian duct
m.c.—vaginal cul-de-sac
ov.—ovary
p.v.s.—posterior vaginal sinus
rect.—rectum
r.l.v.—right lateral vagina
r.ur.—right ureter
r.ut.—right uterus
r.v.c.—right vaginal caecum
sept.—septum between right and left vaginal caeca
u.g.s.—urogenital sinus
u.n.—uterine neck
ur.—ureter
ut.—uterus
ureth.—urethra
u.p.—uterine papillae
vag.—vagina
v.c.—vaginal caecum

PLATE X

Dorsal view of the anterior portion of the urogenital system of *Potoroüs tridactylus*, showing a foetus passing down the left lateral vagina.

Photograph by courtesy of Professor T. T. Flynn.

(For key to reference letters see above.)

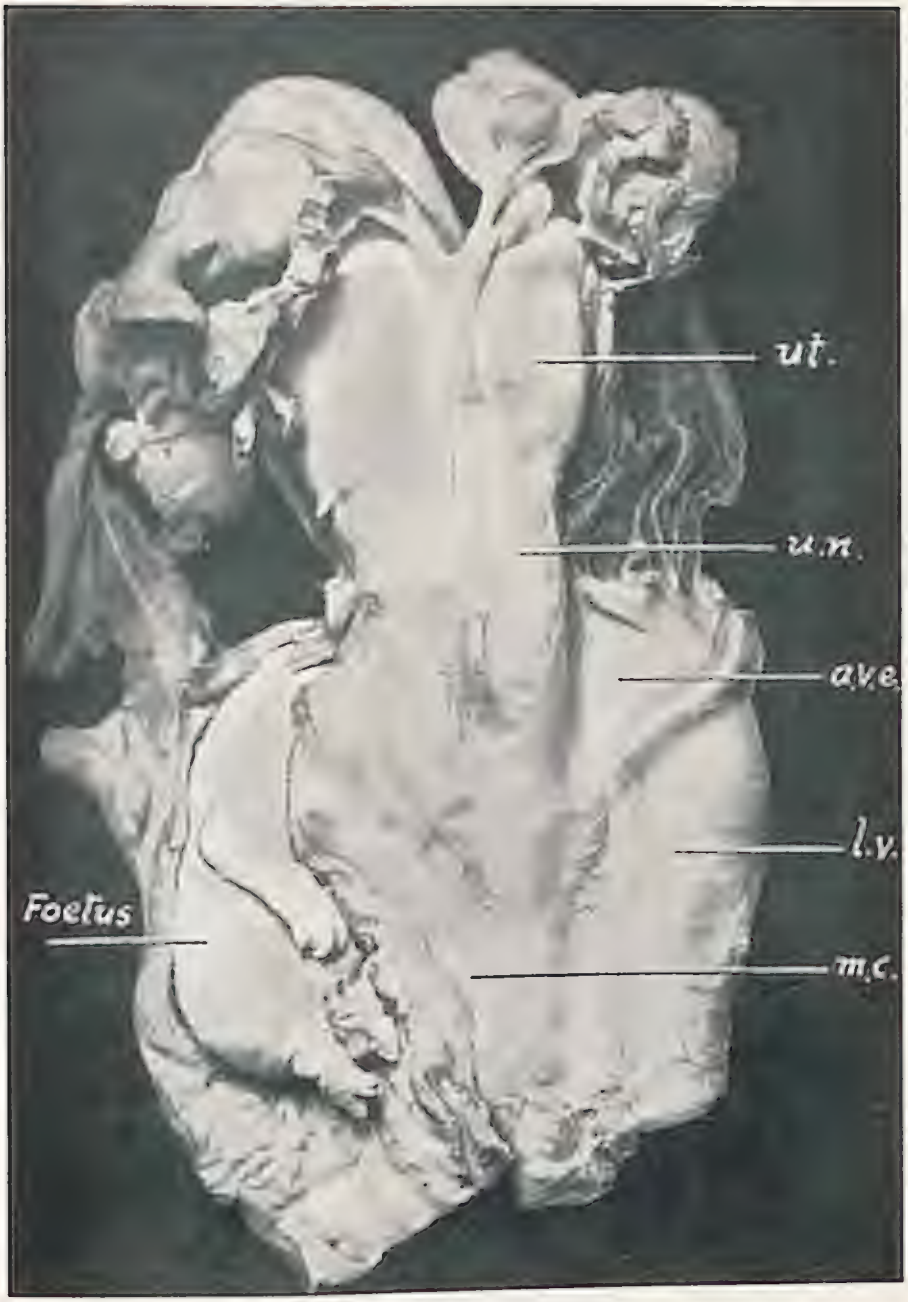

ut.
u.m.
a.v.e.
l.v.
Foetus
m.c.

PLATE XI

Urogenital system of *Potoroüs*.
A—Ventral view x 2.
B—Dorsal view x 2.
(For key to reference letters see p. 98.)

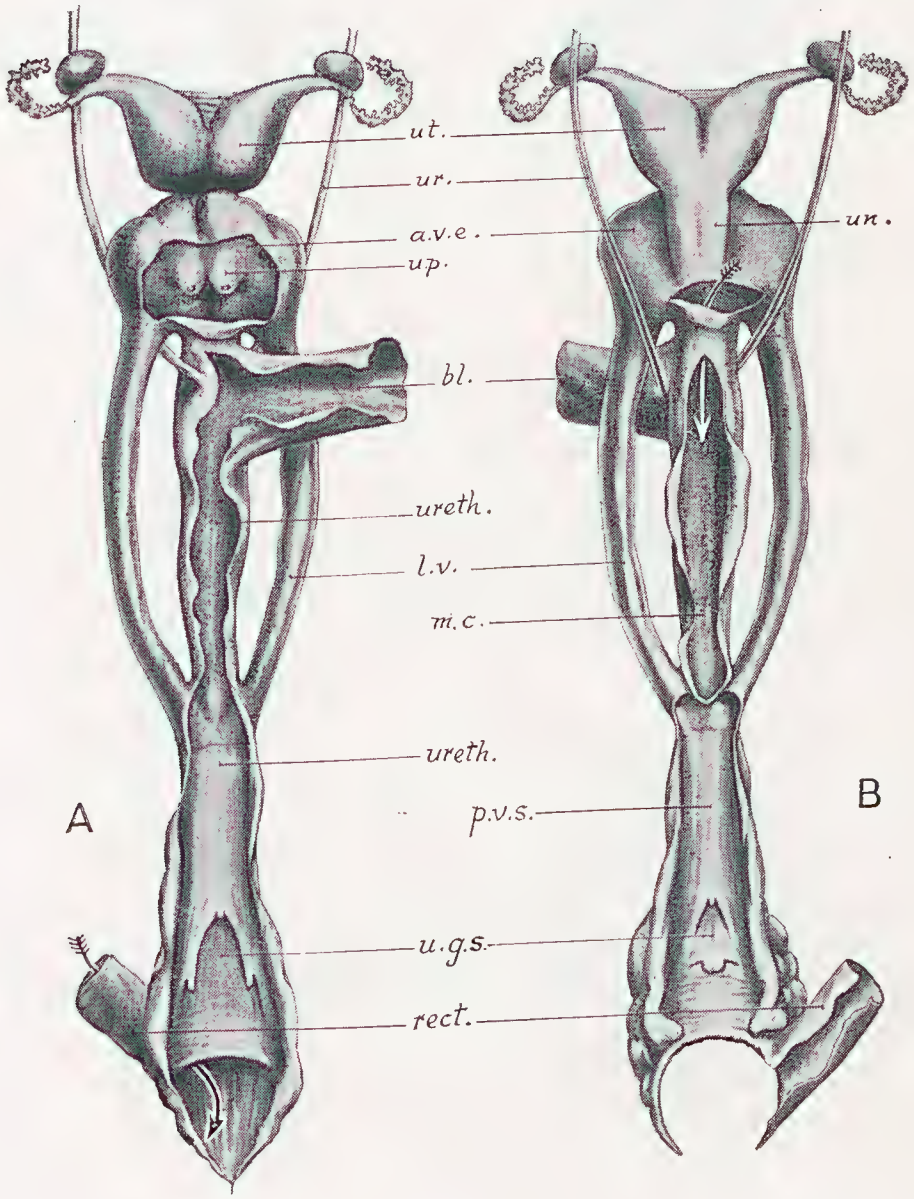

ut.
ur.
a.v.e.
up.
bl.
ureth.
l.v.
m.c.
ureth.
A
p.v.s.
B
u.g.s.
rect.
un.

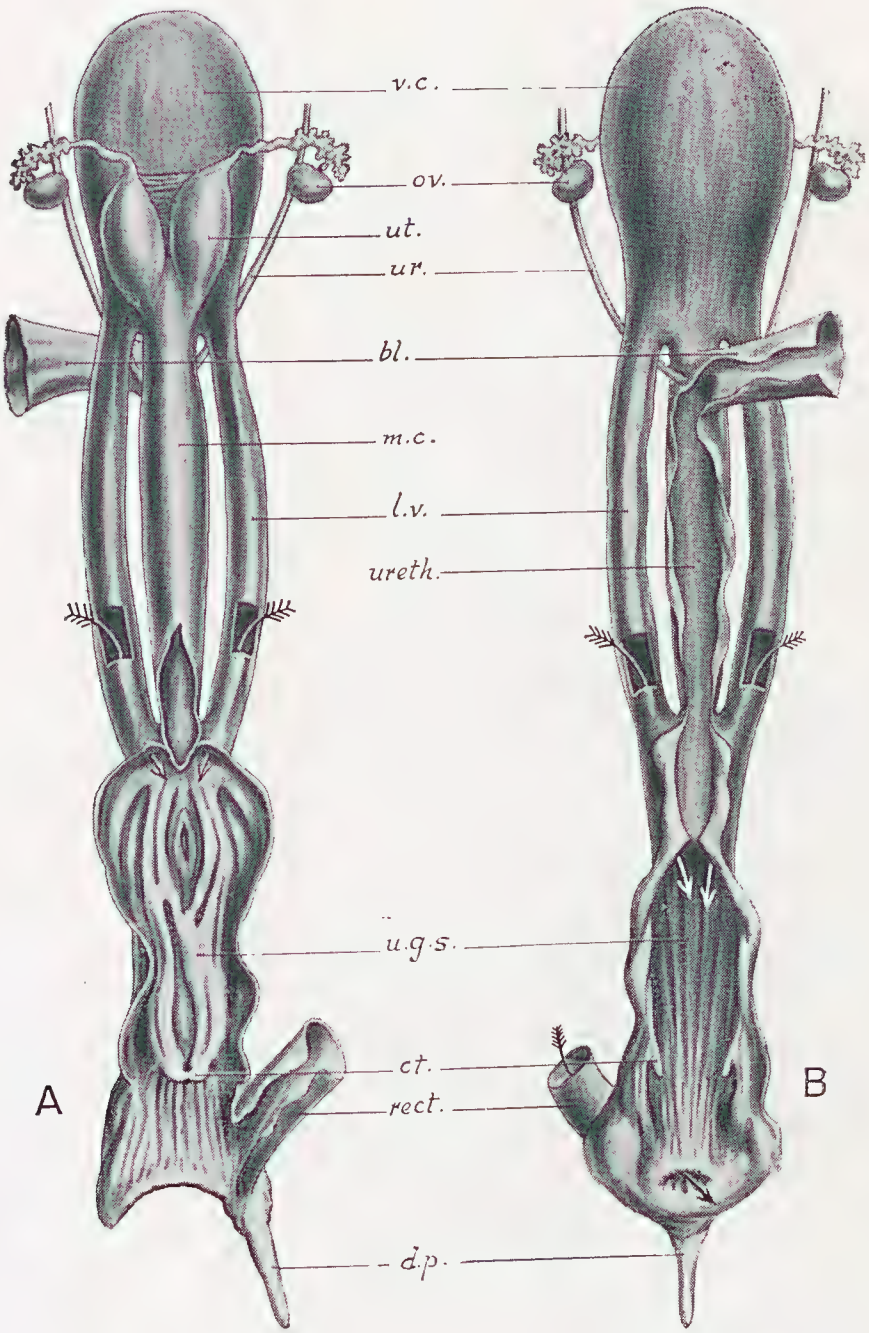
PLATE XII

Urogenital system of *Bettongia*.

A—Dorsal view x 2.

B—Ventral view x 2.

(For key to reference letters see p. 98.)


v.c.
ov.
ut.
ur.
bl.
m.c.
l.v.
ureth.
u.g.s.
ct.
rect.
d.p.
A
B

Early Town Planning in Hobart

By

C. Craig

(Read 18th May, 1943)

Plates XIII, XIV

Of the older cities of the Commonwealth, Hobart alone retains anything of an early colonial character. For this reason any record of its early development is of great interest. The purpose of this paper is to place on record an attempt at town planning (with maps) that was made in 1826, and is not noted in the *Historical Records of Australia.* This report was found amongst some papers placed in the writer's hands by Lt.-Colonel Dumaresq of Mt. Ireh, near Launceston. Lt.-Colonel Dumaresq is a grandson of the Edward Dumaresq who was one of the three signatories to the report.

Hobart was first laid out by Macquarie during his visit in 1811. This is fully reported in the *Historical Records of Australia,* Series III, Volume I, page 512. This should be studied.

In 1825, Governor Arthur appointed three Commissioners of the Survey. These commissioners were Edward Dumaresq, R. O'Connor, and Lieut. Peter Murdoch. Dumaresq was chief commissioner. The main duty of these commissioners was to conduct a general survey of the Island. Another of their duties, however, was to report on the state of Hobart Town, and to make suggestions for the improvement of its layout. It is this report that is attached herewith as an Appendix.

It is unnecessary to comment on this excellent report. The proposed changes were not all put into effect at once, but the important recommendations were all carried out in the hundred years that followed the date of the report.

In any enquiry into early Tasmanian history, it is inevitable that great interest should be aroused in the men who took part in the making of that particular part of history. The following biographical details are therefore given of the three commissioners, all of whom were men of outstanding character.

Lieut. Edward Dumaresq, was one of three brothers, all of whom played a notable part in the early land development of Australia. Their sister, Eliza, had married General Ralph Darling, who became Governor of New South Wales in 1825. The career of each of these brothers has been well described in the Australian Encyclopaedia, so only the broad outlines of Edward's life in Tasmania will be given. Dumaresq visited Van Dieman's Land first in 1824, when he was on leave from the East India Company. This is his description of his impression of Hobart Town at that time:—

'April 7, 1824. Came up the River Derwent to within 8 or 9 miles from Hobart Town. About 7 o'clock the pilot came on board and told us that the "Triton" was to sail the next morning for Madras, and that Major Bell and all

the officers were on board. So I wrote a short letter to Ovans, and the next morning in going up the River met the "Triton" going down. Went on board. Saw Major Bell and family, (a very fine one) and gave the letter for Ovans. Landed about 11 o'clock and went to the hotel, which is only just ready. Feel delighted with everything and the climate is as near perfection as any I have ever known. At present it is exactly like that of England in the fine, clear, cold days of Autumn, but it is said to be very rainy and wet in the winter. New houses of a very neat, clean, and many of a very handsome appearance are rising up in all quarters. Everyone appears to be fully employed and intent on his business. The different appearance of the people of Mauritius and those of Hobart Town seems to me very remarkable. Instead of seeing the poor fellows fagging away in the burning sun, puffing, blowing, and wiping their pale faces with their kerchiefs already soaked through, here they are fine, ruddy faced men who rather seem walking fast to keep themselves warm and for pleasure than from the urgency of their affairs. There is something quite exhilarating in the sensation of being in a place which is so rapidly and wonderfully increasing and in hearing everyone's account of his present prosperity, hopes of the future and well-founded confidence of success.'

When Dumaresq returned in 1825 with the Darlings he was at once appointed Acting Surveyor-General by Arthur. Had Arthur had his own way he would have appointed him permanent Surveyor-General. It was most unfortunate that orders from England prevented him doing so. A full account of this matter is given in the *Historical Records of Australia.* From his reports, it is easy to see that Dumaresq attacked his work with enthusiasm and with success. He undoubtedly laid the foundations for the distinguished work subsequently done by the Survey Department in Van Dieman's Land. For a few years he was Police Magistrate at New Norfolk, but in the early thirties he retired to his grant at Illawarra, near Launceston. Some time later he built a house at Mt. Ireh, where his family have lived ever since. Edward Dumaresq lived to the very old age of 104. Most of those concerned in the dramatic doings of Arthur's time were dead by 1860 and 1870, but long after this Dumaresq was taking an active and alert interest in all the affairs of the day. He lived on into the present century and is well remembered as a 'grand old man' by many people in Launceston and its neighbourhood. He died in 1906.

Peter Murdoch, who was a Lieutenant of the 35th Foot on half-pay, arrived in New South Wales about 1821. He was appointed Superintendent of a horse-breeding establishment at Emu Plains, (Port Stephens, New South Wales). As a reward for his success there, he was granted 2000 acres by Sir Thomas Brisbane about 1824, and in 1826 it was recommended to Governor Darling that he be granted a further 2000. He arrived at Hobart Town on 3rd January, 1825. He was appointed Military Commandant to the Convict Settlement at Darlington, Maria Island, but was only in charge from April to October, 1825. In Van Dieman's Land he received a grant of 2000 acres and a further grant of 1000 acres in 1832. His original grant was at Broadmarsh, where he began farming at the end of 1825. As already noted, he was appointed a Land Commissioner in 1825. In 1828 he rented 1000 acres of dairy farming land, and after 1833 imported Hereford cattle and also horses. In 1832 he and his brother Wallace, who had emigrated in 1828, owned an allotment on Sullivan's Cove where they carried on a wholesale shipping and mercantile trade. In 1834 the brothers sold their wharf property and confined themselves to their farming interests. In 1834 Peter accepted the magistracy of Oatlands, but resigned on 2nd January, 1835. A son was born to his wife on 3rd March, 1836, and another on 8th August, 1837. He

visited England with his wife, but returned on 9th March, 1839. Another child was born at Glasgow. He sold his estate at Oatlands to R. O'Connor. He and his brother appear to have lost interest in Van Dieman's Land after 1840, when they removed to the mainland.

Roderic O'Connor arrived in the Derwent on 5th May, 1824. He had previously paid a visit to the port in 1817 from Port Jackson. On his second arrival his sons, Arthur and William, came with him. Soon after his arrival he received a maximum grant of 2000 acres at Avoca, which he named 'Benham'. He also rented 1000 acres in 1828 in the same neighbourhood. In December, 1831, he is stated to have acquired by grant and purchase 15,000 acres. In 1826 he was appointed third commissioner for the survey and valuation of land in Van Diemen's Land. He held this office for less than a year. In 1828 he was gazetted a Justice of the Peace, and on 11th April, 1829, was appointed Inspector of Roads and Bridges. He was a Legislative Councillor from 1844 to 1848. He was nominated as Member of the Legislative Council under the new semi-elective constitution in 1852. Martin Cash records that after his capture in 1843, O'Connor visited him in his cell. O'Connor was a member of the Avoca Road Trust in 1853. He was frequently a party to legal actions, particularly against Lieutenant Murdoch in 1833, and against John Burnett in 1833, both of which he won. He died at Benham of influenza in 1860.

I am very much indebted to Miss Wayn, Honorary Archivist to the Chief Secretary's Department, for most of the biographical details.

Appendix

Hobart Town,
August 4th, 1826.

His Excellency,
Lt. Governor Arthur,
etc., etc., etc.

Sir,

1. We have the Honor to acknowledge the receipt of the Colonial Secretary's Letter of the 21st ultimo, enclosing the report of the Board of Survey on Public Buildings, and desiring us to report to your Excellency, (having reference to our instructions) on the most eligable [*sic*] situations for the various Public Buildings and Estabments [*sic*] which are required in Hobart Town, considering it as the Seat of Government and Capital of the Island and its Dependencies; and also to point out the reservations which in our opinion it would be advisable to make, for the various Establishments and Departments of Government, and generally for all Public purposes; either for the Health convenience or Gratification of the Inhabitants—

2. In accordance with your Excellency's desire we have made a careful and minute Survey of the site of the Town and its Environs, and deliberately considered on the means and plan, by which the objects

desirable on so important an occasion, may under all attendant circumstances be the most advantageously and economically attained, either at present or at future times—

3. We beg to make our report in the following Order—viz.—

1STLY

As regards the Church and School Establishments—

On the best situations for Churches.
Schools.
Parsonages.
Burial Grounds.

2NDLY

4. As regards the Community generally and collectively—

On Reservations of Ground for purposes connected with the Health, Convenience, or Recreation of the Inhabitants—

1st The future extension of the existing Town.
2nd Public Improvements, Walks, and Drives.
3rd Public Baths and Beaches for Bathing Places.
4th Quays and Landing Places.
5th Town Hall and Market Places.
6th Public Grounds for Games and Exercises.

3RDLY

The Government Civil

5. 1st Domain and Residence for Governor.
2nd Court House.
3rd Residence for Chief Justice.
4th Offices for Departments.
5th Customs House.
6th Stores.
7th Hospital.
8th Lumber Yard and Dock Yard.
9th Penitentiary for Male Prisoners.
10th Penitenitary for Female Prisoners.
11th Jail.

Military

1st Barracks.
2nd Parade Ground for Military Exercises.
3rd Forts, Batteries, and Magazines.
4th Posts of Observations.

1STLY

6. As regards Church and School Establishments.

Churches

See Church A on Plan.

There is at present only one Church built, which is in Macquarie Street it will probably soon be found insufficient for the Inhabitants, we therefore recommend that reservations of Plots of Ground for two

See Church B on Plan. See Church C on Plan.

more may be made, one at the South West end of Macquarie Street, ¾ mile from the present Church to the South West, and the other on the Hill between Elizabeth Street and Argyle Street, about 5 furlongs North Westward from the present Church, which is Eastward of the greater part of the Town.

7. The proposed reservations will be at the most convenient points for the attendance of the Inhabitants at Divine Service, as your Excellency will perceive on reference to the plans which we have the Honor to transmit in accompaniment to his Report.

Schools

8. 1st. For a School House within the Town there is a very good site in Macquarie Street, on the allotment adjoining the Government Mill where we recommend that one should be erected.

9. 2nd. But as we conceive it will be desirable that there should also be a School at a short Distance from the Town, (in which the Scholars may be taught the rudiments of Agriculture,) we recommend that 30 acres should be reserved to the South of it adjoining the reserve for Church B. (see plan,) 20 acres of which are now enjoyed by the Superintendent or Inspector of Schools as a Glebe attached to His Office.

Parsonages

10. 1. Adjoining the last mentioned plot of Ground there are 6 acres well adapted for a Parsonage and which we recommend should be reserved as such.

2. Another Parsonage should be reserved adjoining Church C for which we have marked 4 acres on the Plan.

3. That which is at present enjoyed by the Chaplain may be considered at attached to the Church already built, it is situated in Liverpool Street and comprizes 1⅛ acres, which being in the middle of the Town is all that can be obtained.

Burial Grounds

11. 1. The Burial Ground in use at present being in the Centre of the Town, should be shut up forthwith and a new one of 10 acres marked out and fenced in behind the 1 Mile Stone on the Road to New Norfolk, as shown on the Plan.

2. Another Burial Ground should be reserved to the Westward of the Town of 5 acres, as shown on the Plan.

2NDLY

12. As regards the Community generally and Collectively.

On Reservations connected with the Health, Convenience, or Recreation of the Inhabitants.

1. *The Future Extension of the Existing Town*

The whole of the Land on the North, North-West, and South-East sides of the Town which lies between it and the boundary lines of Grants already made and on the West side within the unconnected line—should be reserved for the future extension of the Town and only given in allotments for Houses and Gardens.

2. *Public Improvements, Walks, and Drives*

13. The part of the Town near the Penitentiary for Female Prisoners is susceptable [*sic*] of great improvement—On the south of the allotment mentioned a Street should turn off Eastward leading in a direct line through the New Road, to the Walk along the South side of Sullivan's Bay.

14. By this very great and most desirable improvement a considerable space (compared with the trivial extent of the alteration required) will be obtained in the best and most valuable part of the Town, and it is moreover necessary to make the plan of it—uniform and correct. The Improvements may at present be made at a trifling Expense by the purchase of one allotment having only two small Houses built on it, which are the only Impediments, but if this allotment is not soon obtained the value of the property will increase, and consequently the Improvements so particularly desirable rendered more difficult and expensive.

15. Considering the great importance of pure Water for the Health of the Inhabitants we beg to recommend that in making the Town Grants and Leases a space of 20 feet should be reserved for the Public on each side of the Rivulet where-ever it is possible, and no building whatever be permitted within that space—unfortunately this has not yet been attended to, but if as much clear space as possible is now reserved, the whole may be gradually obtained.

16. A Bridge should be thrown across the Creek at the North-East end of Macquarie Street, to connect it with Macquarie Point, and which will also be requisite in forming a road from the Town to the Government Domain. From the Bridge a walk and Drive should continue round Macquarie Point turning to the Left (where it approaches the Hill
17. immediately behind,) into the New Town Road by the side of the Domain Hills. It will then go through New Town and join the New Norfolk Road beyond Mr. Brodribb's.

18. On the South side of Sullivan's Bay there will be another delightful Walk and Drive by Mulgrave Battery, and a 3rd may be up Wellington Valley, round the Parsonage and School Ground to Sandy Bay.

19. Other Walks and Drives need not be described, as they will be formed by the different roads and pathways leading to the Interior of the Country, and we may certainly affirm that they will vie with one another in grand and Beautiful Scenery.

3. *Public Baths and Beaches for Bathing Places*

20. Altho' we cannot omit taking notice of so desirable an Establishment as public Baths, yet it is impossible to fix on any particular place for them as this must be determined by circumstances which it is impossible to forsee. But to the South-East of the Town beyond Wellington Rivulet there is a small Sandy Bay, the beach of which should certainly be reserved for Bathing Machines, and Bathing Houses.

4. *Quays and Landing Places*

21. The whole distance from Mulgrave Battery round Sullivan's Cove to Macquarie Point will be reserved either for Mercantile and Government Stores or Batteries.

The whole may therefore be considered as reserved at the same time for Quays and Landing Places, as they can be made where-ever and when-ever they are required.

5. *Town Hall and Market Places*

22. For the first Market Place there cannot be a better site than that which has been already reserved between the Jetty, Macquarie and Campbell Streets. It does not seem to us desirable to turn the whole of the Stream which waters the Town into the New Aqueduct. It affords a good channel for conducting away speedily to the Estuary the great and sudden accassions [*sic*] of water to which the stream is liable, from the Mountain Torrents which come down after very heavy rains, and will secure the market place from being flooded. The Banks
23. of the stream passing through it should be properly built up and wooden Bridges thrown across here and there, or if necessary, the upper part might easily be covered over entirely: but it should remain open towards the lower end, in order that Boats from the Shipping in the Harbour may come into the Market for the supplies which they require.

24. 2. Another Market Place with a Town Hall may hereafter become requisite, and we recommend that the Plot of Ground between Liverpool and Bathurst Streets next to the allotment of the Principal Superintendent of Police, should be appropriated to this purpose (see 2nd Market on Plan).

6. *Public Grounds for Games and Exercises*

25. There is not any Ground so well adapted for these purposes as the flat beyond Wellington Rivulet and behind the Beach above mentioned to be reserved for Bathing. It has been granted to Individuals but if it could be obtained at a reasonable price, we recommend that it should be purchased and reserved for Places of Public Amusement and recreation generally.

26. Macquarie Point (which will hereinafter be mentioned for a military Parade ground) might also be occasionally used for some particular Games, and Exercises.

3RDLY

The Government Civil

1. *Domain and Residence for Governor*

27. Were it not foreign to the nature of an Official report here we would expatiate on the Beauty and Magnificence of the Scenery of the Island generally, and of this spot in particular, so judiciously chosen by General Macquarie for the Government Domain.

28. An agreeable degree of retirement, with immediate vicinity to the scene of Bustle and Business, both Public and Private, is most admirably and conveniently combined, and even the exact spot seems to be pointed out where a House should be erected, by its having (independently of other inducements) one of the finest quarries of Stone which has yet been discovered in the Island. It is therefore almost unnecessary to recommend this piece of Land for those purposes, to which by its admirable adaption it so forcibly recommends itself.

2. *Court House*

29. This is already built in Macquarie Street; the allotment belonging to it should be extended half-way to the water's edge.

3 & 4. *Offices for Department of Government and Residence for Chief Justice*

30. Although it appears by the report of the Board of Survey that the Building at present inhabited by the Lieut.-Governor is in an unsafe and dilapidated state, and is obviously most incommodious and unfit for His Residence; still we consider with some alterations it may be made applicable for various Public Offices, and might with great economy be appropriated to that purpose.

We therefore recommend that when another Government House is built in the Domain, the present one should be turned into Public Offices; and the whole space between the New Road towards Mulgrave Battery and the Ordnance Stores, together with the Government garden in Macquarie Street, should be reserved for the various Offices and Departments of Government for a Residence for the Chief Justice, and for Public Purposes generally.

It will appear from the Plan that Offices for the Departments of Government could not any where be better situated.

5. *Custom House*

31. A space should be reserved on the South side of Sullivan's Bay where marked on the Plan there being sufficient depth of water at this Place for large vessels to come close to the shore.

6. *Stores*

32. The whole distance from opposite the Court House and the Colonial Secretary's Offices, (on the shallow flat below the reserve for Offices of Department, and for Public Purposes generally) should be kept for Government and Public Stores of all description.

7. *Hospital*

33. The Site of the present Hospital has been well selected, and there is space sufficient in the allotment for its enlargement if required. It is central and airy, commanding a fine prospect over the Harbour and Estuary.

8. *Lumber Yard and Dock Yard*

34. These should be on the South side of Macquarie Point on the small inlet forming the mouth of the Town Rivulet.

This situation having the back of the Jetty Line of Merchant Stores, and a muddy Creek in front of it is inapposite [*sic*] for any other purpose than the site of Establishments of the nature of a Lumber Yard or Dock Yard, its adaption for the latter is already exemplified by the only attempt, near the Town at Boat and Ship Building, being made on this Creek; and for the former it is particularly appropriate, being the nearest place to the Penitentiary or Barracks for Male Prisoners where the timber and other bulky and weighty articles on which they have to perform their work can be landed.

35. The Old Slaughter House which occupies part of this Ground should be removed Eastward of where it now stands, to the other side of Mr. Collin's allotment; it will be close on the water-side and shut out from view by the perpendicular banks immediately behind.

9. *Penitentiary for Male Prisoners*

36. For this purpose a large building has been erected and Yard enclosed, in a very proper situation at the angle of Campbell and Bathurst Streets, and its allotment extends from Bathurst to Melville Street.

10. *Penitentiary for Female Prisoners*

37. This building is adjoining the Jail which should be removed and the whole thrown into one for Female Prisoners.

11. *Jail*

38. The Present Jail being reported by the Board of Survey on Public Buildings to be very insecure and totally unfit for the purposes for which it is required, we beg to recommend that a new Stone one should be built on the large vacant plot of ground next to the Penitentiary for Male Prisoners. This site has many advantages which no other possesses; it is elevated and airy and the drains and Sewers will be conducted immediately down a Steep Bank to a small Creek, there is ample space, and above all for aeconomy [*sic*] in building, the best Stone Quarry in the Town is close by; and lastly, though of no trifling importance, it will not spoil the best and most valuable part of the Town, which it would do if built adjoining the Court House.

39. There are two springs of water from the Hills to the North-West and Westward which are never dry, and might be brought through the Jail Yard. Water may be also obtained by Sinking Wells.

The water of the Spring to the Westward and of the wells in this vicinity is used by the Inhabitants for all purposes, but the water of the wells is the best. In quarrying the stone for building the Jail, with a little attention, a fine large Tank may be formed, with the same labor and at the same time that the Stone is raised for the Building.

40. The disadvantage of criminals not being so near the scene of their Trial will be at least counterbalanced by the benefit of Evil disposed Persons having all excuse taken away for loitering in the Vicinity of the Jail, which they now have from its proximity to the Court House, and of which there is too much reason to suppose they avail themselves to contrive and prepare false evidence.

There will be a strong room in the Court House for the confinement of the Prisoners who are for Trial during the day.

Government Military

1. *Barracks*

41. The site for the Barrack Square, it appears to us, was most judiciously chosen by Governor Macquarie.

42. The Lumber Yard has hitherto occupied ground which we conceive should be thrown into the Barrack Square, should Your Excellency be pleased to order the removal of the former. The Barrack Square would then comprize an area of 19 acres affording ample space for a Muster

43. and Drill Parade Ground for ordinary occasions; but as a 2nd Parade Ground for Military Exercises the flat piece of Ground in Macquarie Point is well adapted, and would afford sufficient space to manoevre as considerable a body of troops as will probably be ever stationed in Hobart Town.

3. *Forts, Batteries, Magazines, and Posts of Observation for Telegraph and Signals*

44. The Barrack Hill is a Commanding position but is itself Commanded by an Arm of the High Round Hill, called Woodman's Hill, between Mount George in the Government Domain and Mount Wellington. It therefore appears to us advisable to reserve the Top of Woodman's Hill and that part of the arm running out from it, which commands Barrack Hill, for any Military Works which may be requisite hereafter.

45. These reservations, with Barrack Hill, Mount George (in the Domain), the space round Mulgrave Battery of 6 acres, and Macquarie Point, comprize all that it appears to us need be reserved for Forts, Batteries, Magazines, or other Military Works and Posts of Observation, in the immediate vicinity of the Town.

46. In concluding and presenting our report we beg to assure Your Excellency that in performing the momentous and Important duty confided to us, we have exerted our best Imagement [*sic*] and Ability, and have given our opinions on the very Interesting subjects, to which our attention has been directed, with the most anxious, solicitous and cautious Consideration.

We have the honor to be,
Sir,
Your Excellency's Most Obedient and
Most Humble Servants,

(Signed) E. DUMARESQ,
Chf. Comsr. & Ac. Sur. Gen.

R. O'CONNOR
P. MURDOCH
Commissioners.

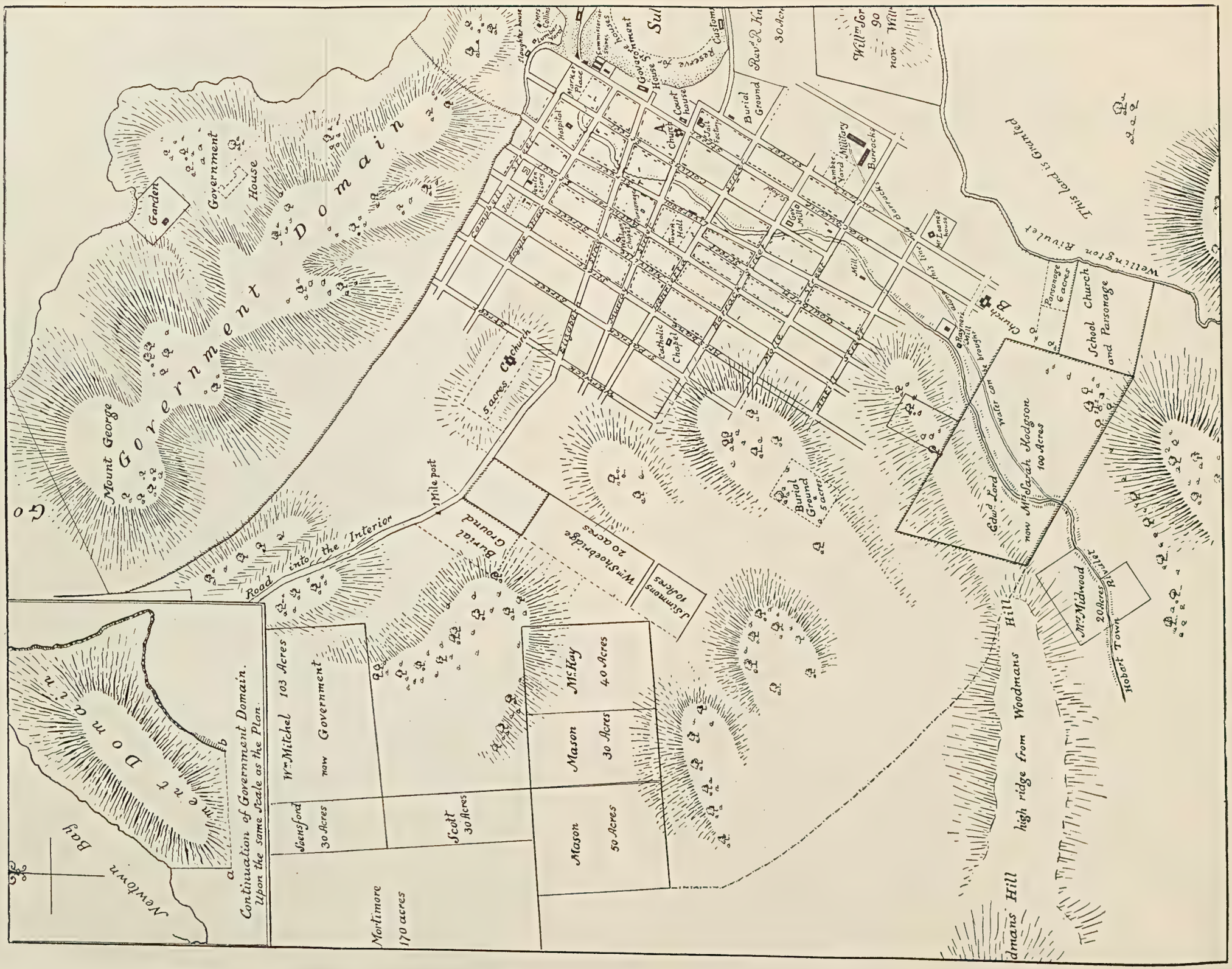
PLATE XIII

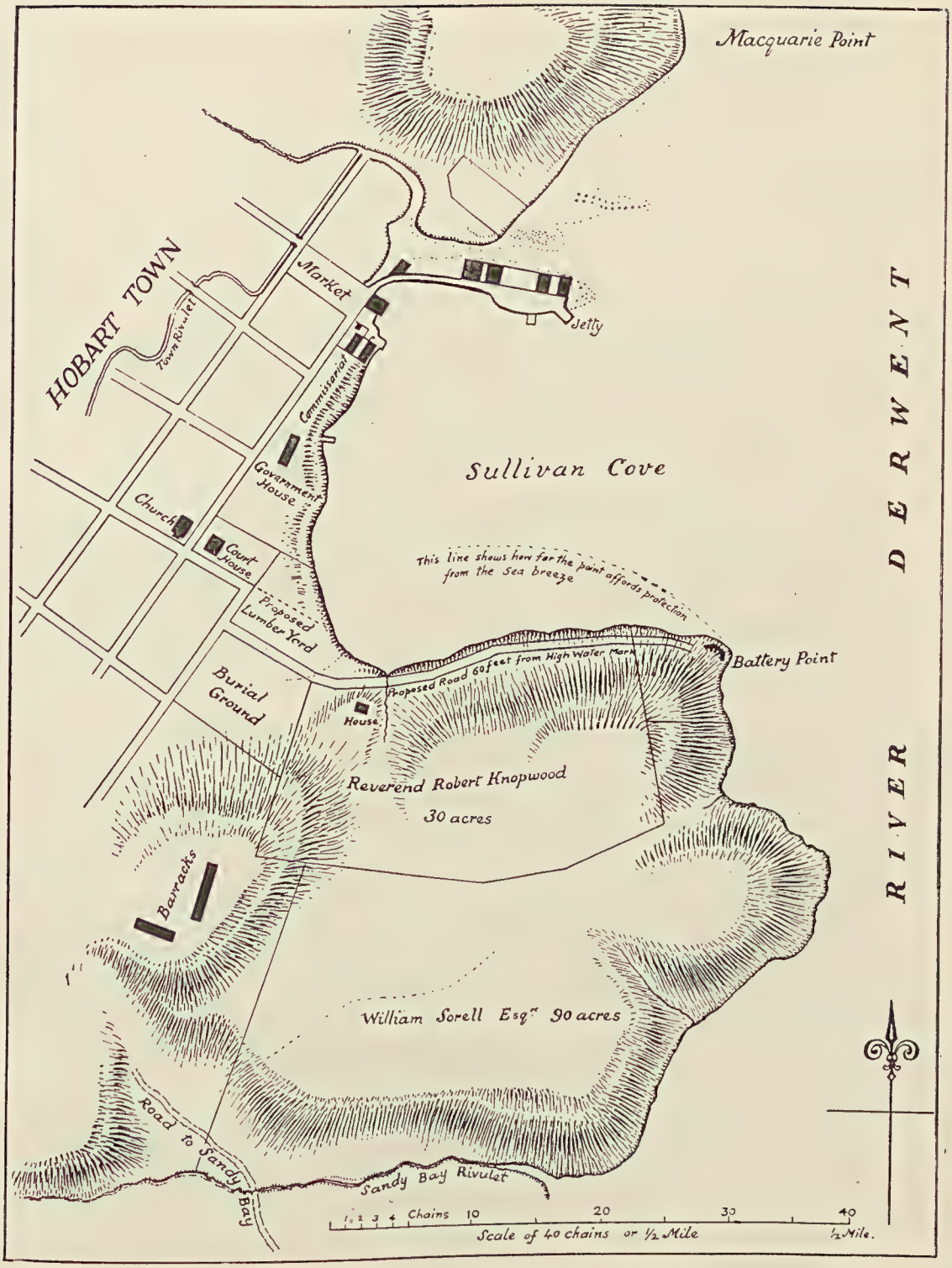
Map of Hobart Town which was attached to the Report made by the Commissioners in 1826. (Copy, with shading simplified, by D. C. Pearse.)

PLATE XIV

Enlarged plan of that portion of Hobart Town in the neighbourhood of the Barracks and Súllivan's Cove, which was attached to the Report made by the Commissioners in 1826.

(Copy, with shading simplified, by D. C. Pearse.)


Government Domain
Mount George
Garden
Government House
Road into the Interior
1 Mile post
Burial Ground
Wm Shoebridge 20 acres
J. Simmons 10 Acres
Wm Mitchel 103 Acres now Government
Scott 30 Acres
Mason 50 Acres
Mason 30 Acres
McKay 40 Acres
Mortimore 170 acres
Newtown Bay
Wellington Rivulet
This land is Granted
School Church and Parsonage
Parsonage 6 acres
Edwd Lord now Mrs Sarah Hodgson 100 Acres
Mrs Midwood 20 Acres
Hobart Town Rivulet
Burial Ground 5 acres
Catholic Chapel
Town Hall
Court house
Hospital
Market Place
Burial Ground
Burracks
Military
Church
Mill
Mr Loane's house
Raynor's Mill
Water can be brought
Hill
high ridge from Woodmans
Continuation of Government Domain.
Upon the same Scale as the Plan.


Macquarie Point
HOBART TOWN
Market
Town Rivulet
Jetty
Commissariat
Government House
Church
Court House
Proposed Lumber Yard
Sullivan Cove
This line shows how far the point affords protection from the Sea breeze
Battery Point
Proposed Road 60 feet from High Water Mark
Burial Ground
House
Reverend Robert Knopwood
30 acres
Barracks
William Sorell Esqr 90 acres
Road to Sandy Bay
Sandy Bay Rivulet
1 2 3 4 Chains 10 20 30 40
Scale of 40 chains or ½ Mile
½ Mile.
D E R W E N T
R I V E R

Government Houses in Hobart Town

By

J. Somerville

(Read 14th March, 1944)

Plates XV-XIX

Although only one hundred and forty years have passed since the first settlement was established on the Derwent, yet in that short period various errors relating to buildings and places have become current, errors which tend to obscure the historical facts concerning those early days.

The present-day stories regarding Lieut. Bowen's house at Risdon serve as an example of such misconception. The approximate position of the building, the first Government House in Van Diemen's Land, is shown in Bowen's plan (Walker, 1889, p. 48). On 3rd September, 1804, Lt.-Gov. David Collins 'ordered all the houses that were at Risdon to be pulled down' (Knopwood), but doubts have been expressed as to whether the order was carried out. However, in 1840, when McCormick, Surgeon on H.M.S. *Erebus* was the guest of Thos. Gregson, whose residence and farm included the site of the first settlement, McCormick wrote in his diary: 'I arose at eight a.m. and strolled to the bottom of the garden, sketched the old ruins of the first house ever built on the island, by its first governor. It now forms the summer-house of the family and the hives for the bees'. (McCormick I, p. 104.)

It is therefore evident that, though Gregson's house was on or near the original site, Bowen's dwelling formed no part of it. This is confirmed by Calder in 1878, who described the remains of the Risdon houses as 'mere broken walls' (Shillinglaw, p. 74, note). Walker (1889, p. 73) writes of 'dilapidated wooden buildings, for many years well known as the residence of Mr. Gregson, the little cottage in front being not improbably Lieut. Bowen's original quarters. About 100 yards behind the cottage, there still stand the ruins of an oven, with brick chimney, which Mr. Gregson for many years religiously preserved as the remains of the first house erected in Van Diemen's Land'. Surely this is contradictory. Had the cottage been regarded by Gregson as Bowen's original home, would he not have referred to it with even greater pride than that with which he exhibited the oven? To-day, 1944, what now remains of Gregson's commodious residence (McCormick I, p. 206) is often pointed out as Bowen's house, whilst photographs and prints of the same house are inscribed as 'The first Government House in Tasmania' or 'Government House, Risdon, 1804'.

Similar misconceptions have arisen in regard to Government House in Hobart Town. To the question, 'How many Government Houses were there in Hobart?' the answer may be three, four, or even six, with a corresponding divergence of opinion as to the position of any one of the three, four, five, or six, as the case may be. This paper, therefore, based on the available historical evidence is an attempt to clarify the existing confusion.

It is also necessary to define the term Government House. Throughout this paper it is restricted to the recognized official permanent residence of the Lieutenant-Governor or other vice-regal representative and does not include any house which may have been hired or lent for the temporary accommodation of the resident or visiting Lieutenant-Governor or Governor. Hence, such buildings as Macquarie House do not come within the scope of this paper.

Collins, with his party, landed at Sullivan's Cove on 20th February, 1804, and in less than three weeks Government House was completed, the Lieutenant-Governor sleeping in his house for the first time on March 9th. (Hookey, p. 17; Shillinglaw, p. 66.) This house has been described as consisting of *(a)* two rooms (*Mercury*, 12/9/1903), and *(b)* three rooms (Giblin II, p. 10), and is said to have been built of spars with a thatched roof (*Mercury*, 12/9/03), of 'rough timber' (Walker, Giblin), whilst still other writers refer to it as 'wattle and daub'. It is generally agreed that it was placed on or near the site of the entrance to the present Town Hall in Macquarie-street, on the rise between Argyle and Lower Elizabeth street. The situation is shown on Harris's sketch, 1804-5. (Walker, 1889, p. 48.)

Moore Robinson (MS.), however, says that within 18 months Collins constructed a rough building to take the place of his canvas tent, and the *Cyclopedia of Tasmania*, 1900, I, p 39, states that it was not till the close of 1805 that Collins left his canvas dwelling. In support of this contention that Collins' house was not erected before the end of 1805, Joseph Holt, General of the Irish Rebels, has been quoted as having written in December, 1805, on the occasion of his visit to Hobart 'His Excellency made me remain with him a good while in his tent'. (Croker II, p. 251.)

In view of the marked discrepancy between the records of Knopwood and Holt, it is worth while to read Holt's statements again. Collins had invited Holt to call in the evening. 'He presented me with some wine and cakes and made me sit down. Governor Collins further requested that at my convenience I would go through the government crop and the settlers' crops'. Holt did so. 'I examined the wheat upon the farms of all the settlers and brought back with me for the Governor samples of both the wheat and the smut. I waited on the Governor'. Here follows Holt's report. 'His Excellency made me remain with him a good while in his tent, and expressed a wish that I would inspect the stock'.

Knopwood's diary contains various references to the Governor's frequent visits to the farm, where he also entertained guests. On 10th November, 1804, Knopwood writes 'We dined with the Governor at his marque at the farm'. Hence we may conclude that Holt visited Collins on that occasion in the Governor's *tent at the farm*. It should also be remembered that the Holt MSS. were written in 1818, founded upon notes which Holt states that he had made when in the Falkland Islands in 1813. (Croker I, p. xxii.) We may, therefore, accept as authentic Knopwood's entry for 9th March, 1804, as the date of completion of the first Government House in Hobart Town.

By December, 1804, bricks and tiles were being made in the settlement, and these were of such quantity that shingles imported from Sydney were no longer needed, and, by 1807, Collins had built a new house of brick, on a site, if not identical with, at least adjoining the first Government House. On 2nd December, 1807, Knopwood records 'A party of gentlemen, including myself, dined at the Governor's in his new house for the first time he dined there'. This new house, even though of brick, was a humble dwelling for a Lieutenant-Governor, for, sixteen months later, when Bligh visited Hobart Town in 1809 he described it 'as a

poor, miserable shell of three rooms, the walls a brick thick, neither wind nor weather proof, lately built and without conveniences'. (*H.R.A.* I, VII, pp. 125-129.)

Macquarie, during his visit in 1811, after denouncing Government House 'as much too small, incommodious and in a state of decay', selected a site for a new Government House on Fosbrook's land on Macquarie Point. 'In the meantime, the present Government House was to be completely repaired with as little delay as possible and shingled, should it appear necessary to do so'. (*H.R.A.* III, I, pp. 456, 459.) Meehan's plan, drawn according to instructions from Macquarie, shows Government House in what is now Lower Elizabeth-street, 'on the south-east side of Macquarie-street, close to the corner of Elizabeth-street'. (*H.R.A.* III, I, p. 825, note.) In Walker (1889, p. 246), Meehan's plan, 1811, has been superimposed in colour on Harris's Plan, 1804-5, and the degree of accuracy varies in different copies. Although Macquarie recognized the need for a new Government House, he gave definite instructions to Giels and Davey that barracks, hospital, and other public buildings must be completely finished before the new Government House was attempted, and then only when time and means permitted. (*H.R.A.* III, I, p. 482.) Repairs to the house had proceeded but slowly, and seven months after Davey's arrival Macquarie wrote 'I was much disappointed to find that even the Government House had not yet been put in sufficient repair to enable you to occupy it'. (*H.R.A.* III, II, p. 33.) However, on 10th May, 1814, a grand ball was given at Government House (Knopwood). Temporary repairs only had been effected, and it was not till barracks, hospital, and gaol had been built that further additions and alterations to Government House were authorized, the foundation stone being laid by Davey in January, 1817 (Hudspeth MS.).

On Sorell's arrival, he reported that 'the state of Government House is uninhabitable, not only with regard to comfort, but even as to security and common decency. I have undertaken some addition and alterations and I am at Mr. Birch's until the house can be occupied' (*H.R.A.* III, II, p. 196), and he was still at Mr. Birch's in December, 1817. During this period, alterations were in progress, the old part being pulled down and the material used in the new rooms, whilst additions, servants' quarters, kitchen, stable, coach-house, and verandah were completed by 1820. (*H.R.A.* III, II, pp. 241-259.) The building was 110 feet long and is commonly known as the 'Sorell Government House', the position being clearly shown on plan, 1824 (Plate XV). It was still regarded as a temporary abode, since Macquarie had by no means abandoned the project of a suitable vice-regal residence on the Domain. This is evident from the resumption of the grants, though Whitehead's farm had been selected as the site in preference to that on Macquarie Point. (*H.R.A.* III, IV, p. 684.)

An account of Macquarie's visit in 1821 is given in General Orders, 16th July, 1821: 'It was with much satisfaction His Excellency beheld the numerous changes and improvements which Hobart Town had undergone since the period of his former visit in 1811. The wretched huts and cottages, of which it then consisted, being now converted into regular substantial buildings and the whole laid out in regular streets, several of the houses being two storeys high and not deficient in architectural taste. The principal public buildings which have been erected are a Government House, a handsome church, a commodious military barrack, a strong jail, a well constructed hospital, and a roomy barrack for convicts'. (*H.R.A.* I, X, p. 501.) Tribute is paid to Sorell, under whom, during a period of little more than four years, all the principal public buildings and the greater part of the private ones had been erected.

The Government House, however, was not a new building, but was the re-modelled 1807 structure, for in an official report to Bathurst, 27th July, 1822, Macquarie writes:—

'List of public buildings and works erected at the expense of the Crown from 1st January, 1810, to 30th November, 1821, both inclusive—*inter alia*—

In Van Diemen's Land at Hobart Town, Derwent

1. The old Government House enlarged and much improved, with some new additional rooms and all necessary out offices, having a garden and shrubbery added thereto, and the whole premises enclosed with a neat paling (7 feet)'. (*H.R.A.* I, X, p. 699.) At this date George's Square was not included in Government House premises, and the fencing thereof forms a separate item. This is also evident from the plan (Plate XV).

That it was but the 1807 house repaired, re-modelled, and added to is confirmed in 1824 by G. W. Evans, Deputy Surveyor-General: 'This is to certify that the present house occupied by the Governor of Van Diemen's Land has ever been in an unsafe state since I first saw it in 1811. The different additions to it has supported it in a great degree; those additions were also added in so loose a manner as to have occasion for abutments to support them; the building is annually giving way, and I consider it quite unsafe as the residence of the Governor of the Colony, as I think it probable that some severe gale of wind will cause the destruction of it'. Evans' opinion is supported by David Lambe, Colonial Architect, a year later. 'The whole of this house is in a very dilapidated and precarious state, the ceilings throughout are cracked and in many parts have fallen in. The foundations of the wall at the eastern end have given way and the whole wall is inclined outwards; this is only supported by three abutments. I should give it as my opinion from the insecurity of the building that it is impossible to repair this house so as to make it permanently a secure residence' (*H.R.A.* III, IV, p. 298), yet this ramshackle building remained the vice-regal residence till 1858. The original three rooms were of brick, but for the alterations and additions generally timber was used (Clyde Papers) and all such additions were but makeshifts, since the proposal to build a new Government House on the Domain had not been abandoned. Arthur, after his arrival, reported to Bathurst that 'The building was in such a ruinous state on my entering it that Colonel Sorell assured me he was always in the greatest alarm when it blew hard, fearing it would come down and bury his family in the ruins'. (*H.R.A.* III, IV, p. 288.)

Bathurst thereupon authorized the construction of a new Government House. A site selected by Macquarie (*H.R.A.* III, VI, p. 237) adjoining the Colonial Gardens was approved by the Commissioners of Survey (Craig, 1944), stones were quarried and part of the foundation had been excavated when the increased dilapidation of the existing Government House became so alarming that it was impossible for the family to continue in it even for another week. At this juncture, a despatch from Bathurst gave instructions to Arthur to suspend work on the new building. (*H.R.A.* III, V, p. 713-714.)

In this emergency, J. Lee Archer, Colonial Architect, suggested that 'the front of the present house might be considerably strengthened by an additional building so as to fill up the recess in the centre and that the eastern end might be equally supported by the like operation, and that the house might thus be rendered habitable in the course of three or four months'. Whilst these repairs were being carried out Arthur's 'very large family was lodged in a most incommodious cottage from the month of February until the end of July'. (*H.R.A.* III, VI, p. 236.) Probably this was the Government cottage at New Norfolk.

Estimates for the new Government House were again prepared in 1827, but by 1828 additions and repairs to the existing building were seriously undertaken and, by 1831, fourteen extra rooms, one being 36 ft. x 23 ft., had been added, offices, and domestic offices extending on a north-south line across the angle of the present Franklin Square near the Hydro-Electric premises, whilst the main building occupied Lower Elizabeth-street, extending over to where the Town Hall entrance now stands. A sketch is given in the Almanac, 1829 (Ross), and additions listed in 1831 (Ross) when 'Government House, the residence of the Lieutenant-Governor and family, the Executive and Legislative Council Chambers, the offices of the Private Secretary, and the offices of the Town Adjutant and Barrack Master were all situated nearly under one roof'. Some of the plans of these additions are in the library of the Royal Society of Tasmania.

In the time of Franklin, the project of a new Government House was revived, and tentative plans drawn by Jas. Blackburn were approved by Sir John Franklin, 1841. The verandah of the old house at that date was 133 feet long and the Legislative Council chamber 74 feet 9 inches long, giving a total frontage of 207 feet 9 inches. The position is shown in Edgar's plan, 1840 (Plate XVI). When compared with Kay's plan, 1850 (Plate XVII), it is evident that few alterations were made during the intervening ten years. In Calder's plan, 1852, the whole area from Arygle to Murray street is marked Government House premises, though some charts show the greater part of the present Franklin Square as the Government paddock. In Sir J. Eardley-Wilmot's time, this area was a park in which a collection of native animals was kept (Meredith).

A description by Melville (1852) is of interest. 'To the right of the market, as you proceed along the edge of the cove or new wharf, is Government House. It is prettily situated on a steep bank. Its frontage is in Macquarie-street and it terminates in the line of thoroughfare or main street called Elizabeth; in its rear it commands an excellent view of the harbour. The house itself is a disgrace to the colony. It consists of a mass of buildings arranged with no plan or order, the whole rookery being composed of a mass of additions made as more room was required by successive occupiers'.

Work on the new Government House commenced by Franklin was suspended after the arrival of Eardley-Wilmot, and the erection remained in abeyance until 1853, when an entirely new plan less extensive in style was adopted. Work on this new plan was commenced in 1853, and this new Government House was occupied by Sir H. E. Fox-Young in 1858.

As the new Government House neared completion, negotiations for the disposition of the grounds and buildings of the old Government House were in progress, and the City Council resolved 'To petition Parliament for a site, such site to be selected from the land at present occupied with Government House' (Minutes, 31/8/57) and in 1858, the ballroom and allotment were reserved for petitioners (Plate XVIII, fig. 1). As soon as the premises were vacated steps were taken for the continuation of Elizabeth-street from Macquarie-street through Government House to Morrison-street and the City Council block was fenced (Plate XVIII, fig. 2). Within five years, all traces of Government House had disappeared and the *Mercury*, 6th January, 1863, stated 'If any of our absentees who can only remember the uncouth and mean looking Government House of former days with its miserable outhouses were soon to return to Hobart Town, they would gaze with pride and pleasure upon the great improvements which have been effected', and again on 19th February, 1863: 'Levelling the site for the Franklin monument is proceeding with considerable rapidity. The large gum trees which have been left growing since the first settlement of the colony in 1804 are in progress of removal' (Plate XIX).

It is evident, therefore, that there were two Government Houses in Hobart Town, both situated in Macquarie-street. The first a wooden building, near the entrance of the present Town Hall, was occupied by Governor David Collins, 9th March, 1804, till the close of 1807. The second, consisting of three rooms, built of brick adjoining the first, was occupied by Collins, December, 1807. This building with many alterations and additions gradually extended southwards across Lower Elizabeth-street and finally into the corner of the present Franklin Square. This second Government House served successive governors from Collins to Fox-Young, 1807-1858. Its position is clearly shown in the accompanying plans and may also be seen in Duterrean's picture of Elizabeth-street, Hobart Town, 1836, now in the Tasmanian Museum.

Acknowledgment

I am indebted to the Government Archivist for permission to examine old files, to the Secretary for Lands for tracings of early plans, and to Mr. R. Morris for the loan of photographs.

[It should be noted that owing to circumstances, over which the writer and the editors had no control, the quotations given do not show the original orthography, and eliminations are not marked,—Editors P. and P.]

References

Clyde Papers, 1941.—Clyde Company's Papers, 1821-35.

Craig, C., 1945.—Early Town Planning in Hobart. *Pap. Proc. Roy. Soc. Tas.*, 1944 (1945).

Croker, T. C., 1838.—Memoirs of Joseph Holt. Two volumes.

Giblin, R. W., 1939.—Early History of Tasmania, Vol. II.

Hookey, M., 1929.—Bobby Knopwood and His Times.

H.R.A.—Historical Records of Australia, Series I, Vols. VII, X; Series III, Vols. I-VI.

Hudspeth, W.—(MS.) Government Houses in Hobart.

McCormick, R., 1884.—Voyages of Discovery in the Antarctic and Arctic Seas, Vol. I, 1839-43.

Melville, H., 1852.—Australasia and Prison Discipline.

Meredith, L. A., 1881.—Tas. Friends and Foes.

Moore-Robinson, J.—(MS.) Tasmanian Government Houses.

Shillinglaw, J. J., 1878.—Early Historical Records of Port Phillip.

Walker, J. B., 1890*a*.—The English at the Derwent and the Risdon Settlement. *Pap. Proc. Roy. Soc. Tas.*, 1889 (1890), pp. 65-90.

———, 1890*b*.—The Foundation of Hobart by Lieut. Governor Collins. *Pap. Proc. Roy. Soc. Tas.*, 1889 (1890), pp. 223-247.

(These two last papers are reprinted in the Walker Memorial Volume 'Early Tasmania', 1902.)

PLATE XV

Part of Plan of Hobart Town, 1824. (Lands and Surveys Department.)

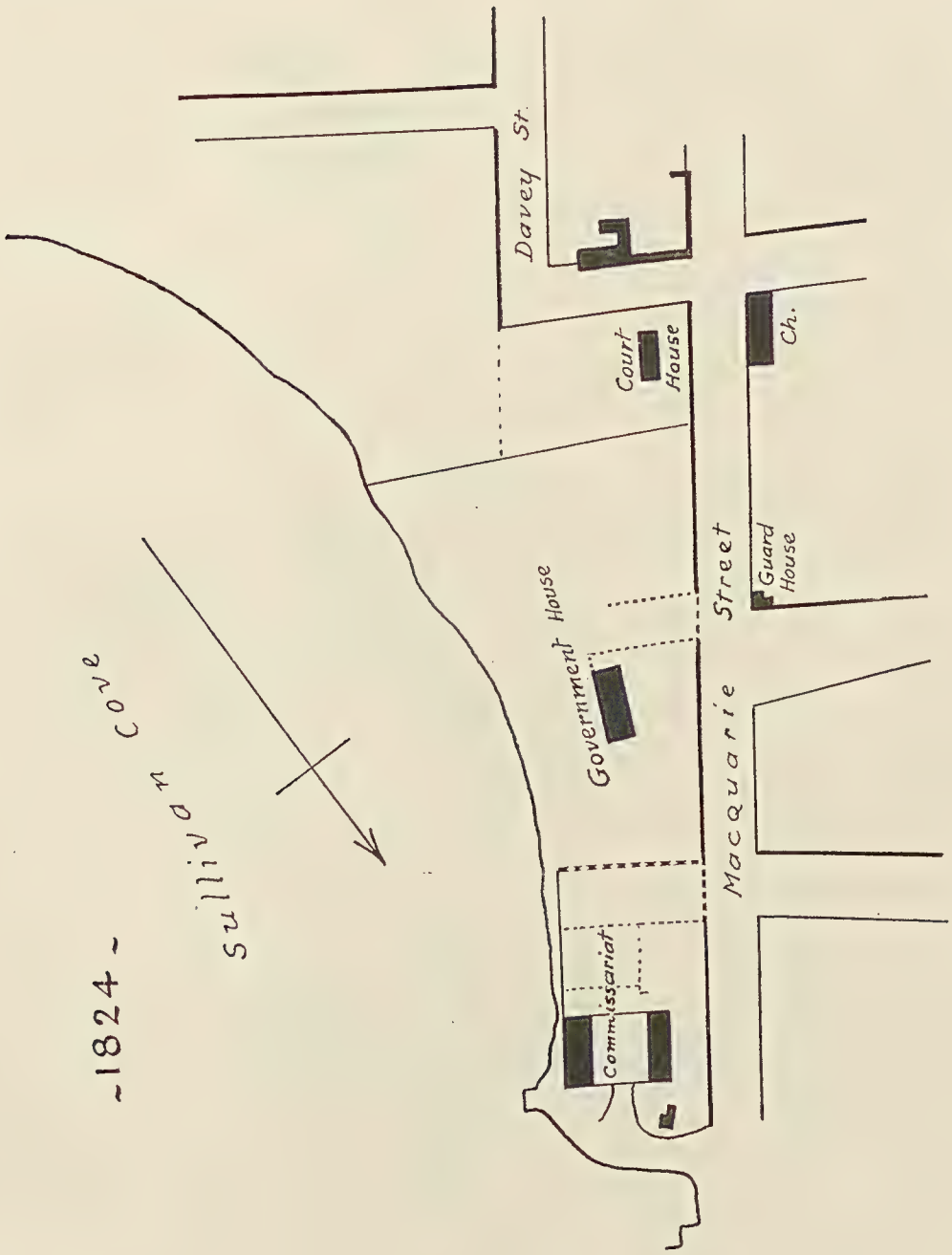
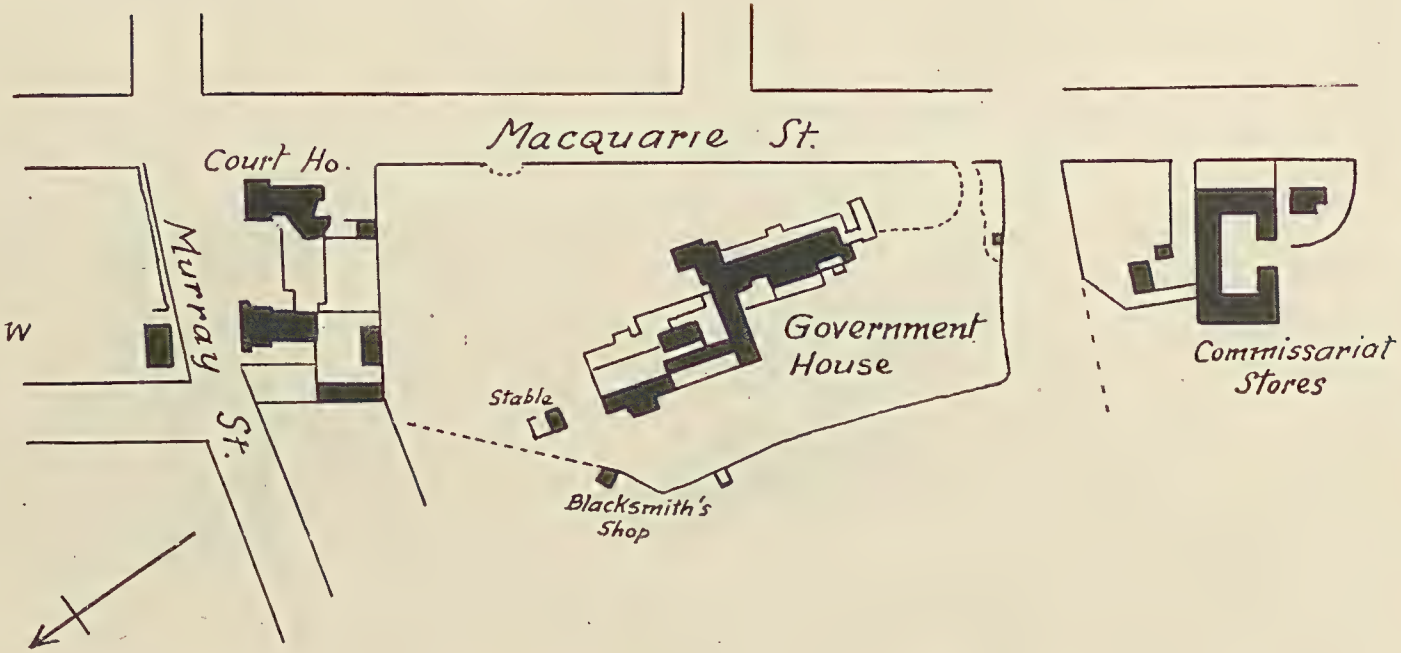

-1824-
Sullivan Cove
Davey St.
Court House
Ch.
Government House
Guard House
Macquarie Street
Commissariat

PLATE XVI

From Plan of Hobart Town, 1840. (Lands and Surveys Department.)



Champ, Surveyor General. F.S. Edgar, Draftsman ~ 1840

PLATE XVII

From Plan of Wharves, Hobart Town. W. P. Kay, September, 1850. (Library Roy. Soc. Tas.)

From Plan of Wharfs Hobart Town.
After Wm. P. Kay Sept. 1850.
PROPOSED NEW STREET
GOVERNMENT HOUSE
MACQUARIE STREET
ELIZABETH STREET
ARGYLE STREET
Proposed Dry Sheds
NEW MARKET SHEDS
COMMISSARIAT STORES
Government Cottage

PLATE XVIII

FIG. 1.—Ballroom, Government House, used as Municipal Offices, 1858-1865.
FIG. 2.—Macquarie-Elizabeth streets, corner of block acquired by the City Council, 1858.

PLATE XIX

Government House, Hobart, 1847. Showing the large gum trees on the site of the present Franklin Square.

The Royal Society of Tasmania

1944

Patron:

His Majesty the King.

President:

His Excellency Sir Ernest Clark, G.C.M.G., K.C.B., C.B.E.

Vice-Presidents:

W. L. Crowther, D.S.O., M.B., 1943-44.

V. V. Hickman, B.A., D.Sc., 1944-45.

Council:

R. G. Brett, B.Sc., 1944, 1945, 1946.

A. L. Meston, M.A., 1944, 1945, 1946.

H. Allport, LL.B., 1944, 1945.

E. E. Unwin, M.Sc., 1944, 1945.

N. P. Booth, 1944.

H. D. Gordon, B.Sc., Ph.D., 1944.

Hon. Secretary and Librarian:

Joseph Pearson, D.Sc. (Manchester), D.Sc. (Liverpool), F.R.S.E., F.L.S.

Assistant Hon. Secretary:

D. C. Pearse, M.C.

Hon. Treasurer:

S. Angel.

Hon. Auditor:

H. J. Exley, M.A.

Hon. Editors of the Papers and Proceedings:

Joseph Pearson.

D. C. Pearse.

Standing Committee:

W. L. Crowther, E. E. Unwin, V. V. Hickman, J. Pearson.

Annual Report, 1944

The Annual Meeting was held in the Society's Room, Tasmanian Museum and Art Gallery, Hobart, on the 14th March, 1944.

The following Office-bearers were elected:—

Vice-President: Under the Society's Rules, Mr. A. L. Meston retired from the office of Vice-President, and Professor V. V. Hickman was appointed in his place (retiring 1946).

Treasurer: Mr. S. Angel.

Council: Under the Rules, Mr. W. H. Clemes and Mr. L. Cerutty retired from the Council, and the following members were elected to the Council in their place:—

Mr. A. L. Meston (retiring 1947).

Mr. R. G. Brett (retiring 1947).

Also one member was required to take the place of Professor V. V. Hickman, who was elected Vice-President, and Mr. E. E. Unwin was elected for two years.

The Council made the following appointments at its first meeting:—

Hon. Secretary and Librarian: Dr. Joseph Pearson.

Hon Assistant Secretary: Mr. D. C. Pearse.

Assistant Librarian: Mrs. Clive Lord.

Standing Committee: Dr. W. L. Crowther, Mr. E. E. Unwin, Professor V. V. Hickman, and the Secretary.

The Council elected the following two Trustees to serve on the Board of Trustees of the Tasmanian Museum and Art Gallery:—Mr. W. H. Clemes and Mr. E. E. Unwin.

Twelve meetings were held during the year (see proceedings for abstracts of papers). In addition, scientific papers were submitted for publication and have been printed in the present volume.

Library

During the year 332 volumes were added to the Library in addition to a number of reports and pamphlets from British and foreign institutions and learned societies. The number of institutions on the Exchange List for the year was 270. Extending the practice which at first was confined only to European countries, it has now been decided to withhold all British and foreign exchanges until the conclusion of the war, with the exception of a few special cases. The Library now consists of 20,756 volumes.

The sum of £42 10s. 3d. was spent on books during the year, and the account allocated as follows:—

	£	s.	d.
General Fund	21	4	6
R. M. Johnston Fund	13	15	9
Morton Allport Memorial Fund	7	10	0

Resignation of Mrs. Lord.—Owing to failing health Mrs. Lord asked to be relieved of her duties in the Library, which she had carried out with conspicuous success since 1933. Mrs. Lord has rendered valuable service to the Society's Library during this period, and it is mainly because of her enthusiasm that the great improvement seen in the Library was due. Members recorded in the Minutes of their meeting, dated 14th March, 1944, their appreciation of Mrs. Lord's services to the Society.

Miss Helen Taylor was appointed in Mrs. Lord's place on 3rd April, 1944, and in consequence of this new appointment the Library is now open to members at the following times:—Monday to Friday, 10 a.m. to 12.45 p.m. and 2 p.m. to 4 p.m.

Membership

The Society consists of the following members:—

	1943.	1944.
Honorary Members	2	2
Corresponding Members	3	2
Life Members	6	6
Ordinary Members	220	268
Associate Members	3	7
	234	285

During the year 19 names were removed from the list of Ordinary Members owing to deaths, resignations, etc., and 70 new members were elected, two of these being Life Members, 60 Ordinary Members and eight Associate Members. Also one Associate Member became an Ordinary Member.

Deaths

The Council regrets having to record the deaths of the following members during the year:—Miss B. B. Adams, Dr. B. A. Anderson, Dr. A. H. Clarke, Mr. S. E. Deegan, Lt.-Colonel H. Foster (Life Member since 1890), Mr. R. W. Legge, Mrs. J. A. McElroy, Mr. E. E. Unwin.

Dr. A. H. Clarke joined the Society in 1896 and, though an invalid for several years before his death, was a keen member of the Society and in earlier years served on the Council on many occasions and also acted as Vice-President. He was also a member of the Medical Section of the Society. Dr. Clarke died in June, 1944, and by the terms of his will the Society will receive a bequest of £100.

Mr. E. E. Unwin joined the Society in 1923 and served on the Council for many years and was Vice-President on more than one occasion. He gave several lectures before the Society and was a frequent speaker at the Society's General Meetings. He was an enthusiastic member of the Education Section of the Society. He died suddenly on 20th September, 1944.

Mr. R. W. Legge made himself an authority on the stone implements of the Tasmanian Aboriginals and assisted the authorities of the Tasmanian Museum in an advisory capacity with reference to the Ethnographical Collections.

Lady Clark

The Council also records with regret the death of Lady Clark, wife of the President of the Society, His Excellency Sir Ernest Clark. Lady Clark showed a

keen interest in the affairs of the Society and, in the midst of a full life, found time to attend most meetings of the Society. She died on 5th September, 1944, after a short illness. A message of condolence was sent to His Excellency, and at the General Meeting held on 11th September, 1944, references were made to her death.

Future Policy of the Society

Particular mention should be made of the Special Meeting of the Society held on 8th February, 1944, in order to give members an opportunity of discussing the future policy of the Society. A full account of the proceedings of this meeting is given on page 121 in the Abstract of Proceedings.

Alteration of Rules

Arising out of the discussion which took place at the above Special General Meeting, certain alterations of Rules were passed at a special meeting held on 9th October, 1944 (see Abstract of Proceedings for that date). Particular mention should be made, however, of the alteration in Rule 33, which affects the basis of membership for Ordinary Members of the Society. By resolutions passed by the Special General Meeting on 9th October, 1944, it was decided that from the 1st January, 1945, two classes of Ordinary Members should be recognized:—

(1) £1 10s. for those Ordinary Members who choose to receive the Papers and Proceedings; and

(2) £1 1s. for those Ordinary Members who do not wish to receive the Papers and Proceedings.

Monthly Meetings

It should be noted that during the year the monthly General Meetings reverted to the original day, namely, the second Monday in the month.

Gifts to the Society

His Excellency the Governor, one copy of Who's Who, 1943.

The Council wishes to place on record their appreciation of a valuable gift of 230 books made by Mrs. Lord to the Library on the occasion of her retirement. These books comprise part of the library brought together by her late husband, Mr. Clive Lord, formerly Secretary to the Society.

The Council also wishes to record a valuable gift of 58 volumes of 'The Mercury' from the year 1860 to 1891, with one or two omissions, from Mr. J. H. S. Munro, of Zeehan.

Mr. J. E. Heritage, Launceston, presented 2 volumes of Caldwell's Journal of the United Service Institution, giving a description of Sir John Franklin's overland journey to Macquarie Harbour.

Mr. C. E. Boyes presented the diary of G. T. W. B. Boyes, 13 volumes, 1823-1824, 1829-1835; also a document appointing Joseph Hone Public Commissioner of Insolvent Estates for Hobart Town, dated 2nd August, 1839.

Mr. A. L. Butler, volume 8 of the Avicultural Magazine.

Dr. W. L. Crowther, 2 volumes of the Medical Directory, 1941 and 1942.

Facilities for Members Visiting Other States

There have been inquiries from members as to whether membership of the Royal Society of Tasmania carried with it any privileges in the various Royal Societies in Australia. The Council has been in touch with all the Royal Societies on the mainland and the result is that there is now a reciprocal arrangement whereby members of the Royal Society of Tasmania, bearing a letter of introduction from the Secretary of the Royal Society of Tasmania, will be allowed to use the Library and to attend any meetings of the Royal Societies in the different States.

Tasmanian Association of Scientific Societies

During the year seventeen scientific societies in Tasmania, including the Royal Society of Tasmania, have formed the Tasmanian Association of Scientific Societies. The main objects of the Association are to bring the individual societies into closer contact with each other, to arrange joint meetings and to provide the general community with information about scientific progress and the relation of science to modern life.

Dr. J. Pearson was elected President, Mr. L. Cerutty, Hon. Secretary, and Mr. A. S. Gill, Hon. Treasurer.

Printing of Papers and Proceedings

Once again the Government has very generously printed the Papers and Proceedings. The Council wishes to record its appreciation of this assistance.

THE ROYAL SOCIETY OF TASMANIA.

GENERAL FUND.

Statement of Receipts and Payments for Year ending 31st December, 1944.

RECEIPTS.	£	s.	d.	£	s.	d.
Brought forward from last Account				14	3	5
Subscriptions				279	18	0
Sale of publications, rentals, etc.				16	17	9
Transferred from Memorial Funds—						
R. M. Johnston Fund	13	15	9			
M.A.M. Fund	7	10	0			
				21	5	9
				£332	4	11

PAYMENTS.	£	s.	d.
Salaries	119	6	8
Petty cash	35	0	0
Lighting	14	13	5
Library	67	8	6
Stationery	22	18	11
Miscellaneous	18	7	5
Insurance	9	17	8
Reserve Fund	35	0	0
Northern Branch (¼ of 24 subscriptions)	8	8	0
	331	0	7
Balance to next Account	1	4	4
	£332	4	11

S. ANGEL, Hon. Treasurer.
H. J. EXLEY, Hon. Auditor.

W. E. L. CROWTHER, Vice-President.
JOSEPH PEARSON, Hon. Secretary.

Balances in Royal Society Funds, 1944.

	£	s.	d.
Reserve Fund	219	15	7
Life Membership Fees	46	2	6
Clive Lord Memorial Fund	33	5	4
R. M. Johnston Memorial Fund	3	4	7
Morton Allport Memorial Fund	Nil		

Abstracts of Proceedings

8TH FEBRUARY, 1944

Special Meeting

A Special Meeting was held in the Society's Room, Tasmanian Museum, on this date. The President, His Excellency the Governor, presided.

The business of this meeting arose out of a discussion which took place at the General Meeting held on the 16th November, 1943.

The Honorary Secretary submitted a report from the Council for the consideration of members, and after considerable discussion the members agreed that the following recommendations be submitted to the Council:—

Papers and Proceedings.—The present scientific standard of papers should not be lowered.

Library.—A full-time Librarian should be appointed and the Government should be asked to provide an annual subsidy to cover the Librarian's salary

Subscription.—Members should be asked to give their views on this matter and a circular should be sent to members asking them to indicate whether—(1) The subscription should remain as at present, namely £1 1s. per annum, including a copy of the Papers and Proceedings; (2) Ordinary Members who decide not to receive the Papers and Proceedings, pay a subscription of £1 1s.; (3) Ordinary Members who wish to receive the Papers and Proceedings pay a subscription of 30s.

Fellows.—It was recommended that no provision be made for the appointment of Fellows in addition to Ordinary Members.

Sections.—That no steps should be taken at present to inaugurate sectional meetings, though individual members could, if they so desired, band together to form a section on any one subject.

Visitors.—It was agreed that the rule permitting each member to introduce two guests should be retained, but that the public should be invited to Memorial Lectures and other special lectures.

Type of Lecture.—It was agreed that the lectures should not be less technical, but that an effort should be made by lecturers to present their lecture in such form and in such language that the non-scientific members of the Society would be able to understand them. More emphasis should be placed on the value of discussions which should follow the lectures and that, if necessary, the lectures should be made shorter in order to make more time for discussion.

Publicity.—It was recommended that the present policy of not advertising the General Meetings in the press should be retained, but in the case of Memorial Lectures and other special lectures it would be advisable to invite the public through advertisements placed in the 'Mercury'.

Exhibits.—A special feature should be made of exhibits at the monthly meetings.

It was pointed out by the President that, although these recommendations were to be submitted to the Council, it should be understood that the administration

of the affairs of the Society was a matter for the Council to decide. At the same time, it was pointed out that it was the desire of the Council to ascertain the views of members on the various points which had been raised and in this respect the discussion would prove of the greatest help to the Council.

14th March, 1944

Annual Meeting

The Annual Meeting was held in the Society's Room, Tasmanian Museum. The President, His Excellency the Governor, presided.

The following were elected Office-bearers and members of the Council for 1944:—Professor V. V. Hickman was elected Vice-President in the place of Mr. A. L. Meston, who retired under Rule 12; Mr. A. L. Meston and Mr. R. G. Brett were elected in the places of Mr. W. H. Clemes and Mr. L. Cerutty, who retired under Rule 21; Mr. E. E. Unwin was elected to take the place of Professor V. V. Hickman, who was elected Vice-President; Hon. Treasurer, Mr. S. Angel; Hon. Auditor, Mr. H. J. Exley; Hon. Secretary, Dr. J. Pearson; Assistant Hon. Secretary, Mr. D. C. Pearse.

The following were elected members of the Society:—Miss M. Hookey, Professor A. Burn, Mr. A. D. Helms, Mr. E. M. Johnson, Mr. A. W. Maxwell, Mr. O. V. Morris, Mr. C. von Stieglitz.

Dr. J. Pearson gave a talk on 'Government Houses in Macquarie Street', which had been prepared by Miss J. Somerville, who was unable to be present owing to illness. (See page 109.)

18th April, 1944

A meeting was held in the Society's Room. The President, His Excellency the Governor, presided.

The following were elected members of the Society:—Ordinary Members: Miss R. Blakney, Miss M. T. Butler, Miss D. Knight, Miss I. McAulay, Mrs. James Murray, Mrs. M. Murray, Mrs. C. Needham, Mrs. H. C. Orbell, Mrs. A. B. Raymond-Barker, Mrs. H. Shaw, Miss I. D. Travers, Mr. H. Amos, Mr. N. C. Ashdown, Mr. B. H. Blackwood, Mr. C. E. Boyes, Mr. V. A. Bromley, Mr. R. A. Clive, Mr. T. G. Collins, Mr. G. C. Cramp, Mr. J. A. T. Cruickshank, Mr. H. L. Dakin, Dr. C. A. Duncan, Mr. N. D. Ferguson, Mr. F. Fernyhough, The Very Rev. H. P. Fewtrell, Mr. T. Fitzgerald, Mr. J. H. Gould, Mr. Q. J. Henderson, Major A. W. Hutchin, Mr. T. Jacobs, Mr. L. R. Jensen, Mr. H. Kelly, Dr. J. Magner, Dr. P. A. Maplestone, Mr. W. B. Mather, Dr. J. P. Miller, Mr. R. Morris, Mr. V. S. Murphy, Mr. H. C. Orbell, Mr. A. J. Payne, Capt. D. C. Pearse, Mr. J. Pearson, Mr. R. J. Shield, Mr. W. C. Snow, Mr. G. A. Walch; Associate Members: Miss M. Fyvie-Watt, Miss M. Hart, Miss N. Smith, Mr. K. G. Brownell, Mr. J. D. Moir, Mr. J. H. Rough.

Alteration in night of General Meeting:—It was agreed that the General Meeting should be held on the second Monday of every month instead of the second Tuesday.

Dr. Crowther stated that the Hon. Secretary had been approached by certain scientific societies in Tasmania who were anxious that an attempt should be made to bring these societies into closer co-operation. The Council had discussed this matter and had agreed that the Royal Society should invite representatives of scientific societies in Tasmania to meet and discuss this question.

Mr. N. H. White gave a demonstration of a label from Mr. William James Farrer's Wheat-breeding Plot at Lembrigg, near Canberra.

Mr. G. C. Israel read a paper entitled 'Some Avenues for Chemical Research in Tasmania' which had been prepared by Professor E. E. Kurth, D.Sc., Mr. G. C. Israel, M.Sc., and Mr. B. J. Ralph, B.Sc. The following is an abstract:—

Many persons have carried out scientific investigations into the natural history of Tasmania since the colony was founded but such work has been largely concerned with the natural sciences. Chemical investigations have been mainly sporadic and connected with the utilization of the mineral wealth of the State. Mineral deposits, while still large, must inevitably decline, and hence chemical investigation should be directed to the exploitation of other resources, particularly those which can be replenished naturally.

The topography of Tasmania, coupled with the abundant water supplies have led to a progressive policy of hydro-electric development and the power available places this State in an advantageous position for the establishment of certain types of chemical industry.

The paper proceeded to deal with some of the desirable chemical investigations relating to undeveloped natural resources peculiar to Tasmania and to the general welfare of the State.

1. *Tasmanite Shale.*—A description of the nature and extent of the Latrobe deposits was given. Efforts had been made to establish an oil extraction industry but these had been commercial failures. Investigations have also been carried out to develop the shale as a source of bitumen. However, research inaugurated at the University has indicated that the shale may provide a useful raw material for the production of varnishes, plastics, and other products, but more work is necessary on this interesting and valuable material.

2. *Beach Sands and Clays.*—The analysis of beach sands with a view to their utilization in the production of glass, pure silica and, perhaps, the rarer elements of their compounds, merits attention in view of the large supply of such sands. Clays also need evaluation because they may prove suitable for the establishment of a ceramics industry.

3. *Wood Utilization.*—The paper proceeded to deal briefly with the question of afforestation and the production of wood as a crop. The uses to which wood may be put were shown diagramatically and included such important products as pulp, essential oils and purfumes, pure chemicals, sugars, alcohol, and plastics. The large variety of chemical products which can be manufactured from alcohol were also illustrated.

In the pulp industry, development is possible by the manufacture of rayon, celanese, etc., but, at present little is known of the suitability of pulp from Tasmanian timbers for such purposes.

During the last few years, the problem of acid hydrolysis of wood has been investigated by the Chemistry Department, University of Tasmania. Descriptions of the nature of cellulose and of the chief processes used in the acid hydrolysis of wood polysaccharides were given. The problem in relation to Tasmania, has been to determine whether such processes are applicable to Tasmanian timbers, and any modifications to those processes. It was also necessary to identify the products of the hydrolysis and the uses to which such products may be put. The results to date had been encouraging and investigations were proceeding.

Investigations were also necessary to elucidate the composition and value of the essential oils to trees indigenous of Tasmania such as the huon pine *(D. franklinii)*. The chemistry of the black wattle *(A. decurrens)* was also worthy of investigation.

4. *Marine Products.*—The prolific growth of sea-weeds around the coast of Tasmania has drawn attention to the possibilities of such as raw materials. Investigations were proceeding on the value of *Macrocystis pyrifera* as a source of alginic acid, which has a wide variety of uses. However, relatively little had been done and, further, the value of these sea-weeds as sources of potash, iodine, agar, and other substances was still practically unknown.

In the field of marine fauna, such problems as the evaluation of fish and fish oils from a nutritional point of view are important.

5. *Foodstuffs.*—Similar nutritional investigations on the various foodstuffs produced in this State would be of undoubted value, especially since the value of foodstuffs is known to vary with climate and soil.

6. *Soil and Water Anaylses.*—Attention was drawn to the fact that no complete soil survey has ever been made in Tasmania. The value of such a survey, together with the attendant chemical analysis, was stressed, since it is known that deficiencies in the amounts of 'trace' elements in soils often has a very marked effect on the growth of both crops and animals. Thus the disease in sheep known as 'coasty disease' had been traced to a cobalt deficiency in the soil. The effect of small amounts of molybdenum on the growth of crops, of iodine on the prevention of goitre, and of fluorine in the production of the proper tooth structure, were also quoted.

In conclusion, the paper stressed the value of the more academic type of investigation as distinct from those investigations of new processes which might have some industrial application.

8TH MAY, 1944

A meeting was held in the Society's Room on this date. Professor V. V. Hickman, Vice-President, presided.

The following were elected members of the Society:—Miss Marjorie Reid, Mr. F. X. de Bavey, Mr. A. Watt.

Dr. C. Duncan delivered an illustrated lecture on 'Human Blood Groups', of which the following is an abstract:—

The three main types of Human Blood Groups—the A, B, O, the M and N, and the Rh factor, were discussed from the following aspects—Evolutionary, Historical, Hereditary, Theoretical Components, and Practical Applications.

A, B, O, figures for the first 20,000 persons tested in Hobart were given (with the permission of the A.D.M.S.) and were as follows:—

AB	3·2%	± 0·08%
A	40·2%	± 0·24%
B	9·4%	± 0·14%
O	47·2%	± 0·25%

Figures were also given for many other races, including Javanese, Papuans, and Australian Aborigines.

The importance of these figures to the anthropologist for the study of the origin and migration of races was indicated.

Finally, tribute was paid to the research workers who, by the investigation of Human Blood Groups, have made blood transfusions the safe life saving operation they are to-day.

5TH JUNE, 1944

A meeting was held in the Society's Room. The President, His Excellency the Governor, presided.

The following were elected members of the Society:—Dr. E. D. Hull, Dr. R. McIntosh, Mr. R. N. Smith.

Mr. W. S. Fairbridge read a paper, which had been prepared by Mr. Maurice Blackburn, entitled 'Developing our Fisheries', of which the following is an abstract:—

The Australian fisheries yield is relatively small, being about 58 million lbs. in a typical pre-war year, or only 0·7% of that of Japan, the leading fish-producing country. Nevertheless, there are prospects of increasing this output, and there is reason to believe that in Australia, as elsewhere, the fisheries yield per manpower unit compares favourably with that of agriculture. In view of the war-time food position there has therefore been ample justification for the policy of the Council for Scientific and Industrial Research in permitting its Fisheries Division to continue its developmental work.

After several years' work by the Division it has been concluded that it might be possible eventually to double our annual output, which would be a valuable achievement, even though the fishery would still only be moderate in size. Any greater expansion seems unlikely, owing to a combination of rather unfavourable factors, of which the most important are the relatively unbroken coastline, relatively narrow continental shelf and only moderate quantities of nutrient salts in the Australian seas. As to specific means of seeking whatever expansion is possible, several have been suggested but only two offer much possibility of making a useful contribution within a short time; they are the establishment of new pelagic or surface fisheries and the extension of trawling or bottom net fishing to new grounds, and these are therefore claiming most of the Division's attention.

Of these two projects, however, the former is of special importance. In various waters of south-eastern Australia there are found, at certain seasons, numerous shoals of tuna, pilchards, horse-mackerel, and sprats. These have so far remained unexploited, since elaborate large nets are mainly needed for their capture and, although these methods work well in some overseas fisheries, they have not so far given satisfactory results here. The Division's vessel 'Warreen' was able to achieve some success with one such net, the lampara, upon Tasmanian sprats in particular, but she was unable to obtain useful results with another much more important type of net, known as the purse-seine. However, the conditions which operated to prevent success with this net, of which bad weather during the fishing season was the most important, seemed to be less marked in south-eastern Tasmania, where there are also

large stocks of fish, especially horse-mackerel, available in the autumn each year; and it was decided to collaborate with the Tasmanian Fisheries Division and private enterprise in a special attempt to prove this gear from different boats. Some successes with this work, which though small were regarded as quite significant and promising, were achieved in 1943; the war-time difficulty of importing sufficient of the kind of netting that experience has now shown to be necessary has prevented any further progress, but it is still hoped to procure this material shortly. If this can be done there is every prospect of developing an important new fishery in Tasmanian waters, providing very large quantities of fish for a rather small output of effort.

In addition to this work, the collaboration between the C.S.I.R. Division and the Tasmanian authority has made it possible to demonstrate the existence of apparently payable trawling grounds in southern Tasmania, and to bring substantial quantities of fish to market; this resulted from the commissioning of the State trawler 'Liawenee' in early 1944, and this vessel is also participating in fisheries research in the stricter sense.

10TH JULY, 1944

A meeting was held in the Society's Room. Dr. W. L. Crowther presided.

The following were elected members of the Society:—Rev. A. A. Ezzy, Mr. G. D. Hubble, Mr. W. H. Southcott.

It was announced that in consequence of the appointment of Miss D. H. Taylor as full-time Assistant Librarian, the hours of opening the Library would be as follows:—Monday to Friday, 10 a.m. to 12.45 p.m. and 2 p.m. to 4 p.m.

Cataloguing the Library.—It was announced that a letter had been received from the State Librarian to the effect that the State Library had asked for the appointment of a cataloguer to carry out the preparation, classification, and cataloguing of books and periodicals belonging to the Library of the Royal Society of Tasmania. It is hoped that this appointment will take effect from the beginning of next year.

It was reported that Mr. J. A. S. Munro of Zeehan had presented to the Society's Library 58 volumes of the 'Mercury' from the year 1860 to 1891, with one or two omissions.

Mr. F. Fernyhough delivered an illustrated lecture on 'The Evolution of Domestic Chair Design', of which the following is an abstract:—

Very few examples of English oak chairs dated prior to 1500 have survived and they are actually seats of state, the form and ornament following the Gothic tradition. In Italy pre-Renaissance chairs are of the folding type for easy transfer from room to room and go under the names of 'Dante' and 'Savonarola' chairs. Renaissance influence expressed in the arts and crafts shows in English chairs from 1600 but marked development is under Charles II bringing French Court fashions at the Restoration. These walnut side-chairs are covered with carving and turning, with arm-chairs richly upholstered in fabrics woven by French refugees. William III, on his accession, employed Dutch and French designers who made the chair an artistic unity as instanced in a set of fine chairs which may be seen to-day at Hampton Court Palace. Final development of walnut chairs came under Queen Anne, with the fiddle-back and cabriole-leg forms predominating.

After various design experiments from 1725 to 1750 following the importation of mahogany into England, Chippendale's genius applied to this perfect medium established the English chair tradition, ably followed by Adam, Hepplewhite, and Sheraton. Chippendale's large mahogany chairs are well-known and usually carry the cupid's-bow form of cresting or top-rail, with cabriole legs and vigorous ball-and-claw feet. Adam and Hepplewhite co-operated to produce fine light chairs in large sets for Adam's classical architectural interiors, the oval and shield backs predominating, with straight taper legs and spade feet. Sheraton, designer only, not producer, introduced the round taper fluted leg into English chair design, usually with square top rail to the back, the back in diamond lattice or baluster form and with the chair-arm springing gracefully forward and down from the top rail to the arm-rest. He designed also, painted and inlaid chairs. Fine chair design ended with Sheraton at the close of the 18th century.

14th August, 1944

A meeting was held in the Society's Room. Dr. W. L. Crowther presided.

Miss D. M. Kahan was elected a member of the Society.

Mr. N. H. White delivered an illustrated lecture entitled 'The Viruses of Plants', of which the following is an abstract:—

Soon after the discovery that plant diseases were caused by fungal and bacterial parasites and non-parasitic causes, some diseases producing mosaics, dwarfing and necrosis in plants were found to be caused by a contagious 'principle' in the plant sap known as a 'virus'.

At first the effects of the viruses on plants were studied and they showed characteristically (i) intracellular inclusions or X-bodies, (ii) necrosis of the phloem, and (iii) the abnormal size and shape of plastids.

Attempts were made to discover the true nature of the virus. Ivanovski and Beijerinck at the close of the last century postulated that the virus was a living infective fluid and that the infective particles could pass through a bacteriological filter. These filterable viruses could not be resolved under the highest powered microscope using white light. By using electrons instead of light and magnets instead of lenses as in the electron microscope the virus particles could be seen. These appeared as rod-shaped structures at a magnification 40,000. Suspensions of viruses generally show a characteristic optical effect known as 'anistropy of flow' or birefringence, which was due to the rod-shaped virus particles being orientated end on end.

Following the determination of the shape and size of the virus particles, efforts were made to isolate and purify the viruses. Vinson and Petre precipitated the tobacco mosaic virus by salting out and showed that it behaved like a chemical substance. Later, Stanley salted out the tobacco mosaic virus and purified it by recrystallization many times. The virus was found to be paracrystals of a protein. In 1937 Bawden and Pirie isolated and purified the Bushy Stunt virus of tomato as normal crystals of a nucleoprotein. The tobacco mosaic virus was also found to be a nucleoprotein. Subsequently other plant viruses have been identified as nucleoproteins.

The outstanding feature of the virus nucleoprotein is its ability to reproduce itself in the living host cells. Virus nucleoproteins are formed in the plant at the expense of the normal proteins of the plant.

The introduction of the electron microscope and the perfection of biochemical technique and knowledge have made possible a more accurate description of the plant viruses. It would seem that the viruses of plants are monomolecular and consist of ribose-nucleoproteins. Their power of multiplication is an inherent property of their molecular pattern which influences other specific molecular patterns within the protoplasm of the host cell. The presence of these abnormal nucleoproteins alters the physiology and structure of cells and so brings about a condition known as a virus disease.

Although botanists borrowed the term 'hormone' from animal physiologists at the beginning of the century, it was not until 1928 that a hormone was actually extracted from a plant. Much difficulty was encountered in the early experimental work because of the very small quantities of hormones available. A new field of research opened up when in 1930-1933 it was found that certain substances extracted from yeast and from animal materials exerted physiological effects similar to those of plant hormones. Certain of these 'growth substances' have now been identified chemically and synthesised. Results of experiments with such growth substances, which are of fundamental importance in plant physiology, have certain practical applications. Some of the present commercial uses of growth substances are to stimulate the rooting of cuttings of both herbaceous and woody plants, to inhibit the development of buds during the storage of potatoes, to prevent the pre-harvest fall of apples and other fruits and to cause the development of seedless fruits in Solanums and other ornamental plants.

11th September, 1944

A meeting was held in the Society's Room. Professor V. V. Hickman, Vice-President, presided and referred to the lamented death of Lady Clark. The Hon. Secretary read a letter which had been sent on behalf of the Council and Members of the Society to His Excellency the Governor on the occasion of Lady Clark's death. Those present then stood in silence in respect to the memory of Lady Clark.

Mr. R. S. McIntyre was elected a member of the Society.

Professor A. L. Dunbabin delivered a lecture entitled 'Aristotle, the Father of Science', of which the following is an abstract:—

Aristotle was born in 384 B.C. in the little town of Stagira, a Greek colony in the peninsula of Chalcidice. Inland were the Macedonians who were a constant danger to the Greek settlements on their coast. Aristotle's father was the friend and personal physician of Amyntas, the father of King Philip. It has been suggested that Aristotle inherited his powers of observation and his interest in biology from his father, the physician. When he was seventeen, his father died and apparently left him well off, for he came to Athens and studied philosophy under Plato for twenty years, and even philosophers cannot live on air. In 347 B.C. when Plato died, Aristotle went to live with his friend and fellow-student Hermeias at a town on the coast of Asia Minor opposite the island of Mytilene. Three years later Hermieas died and Aristotle went to live in Mytilene. It was probably during that period that he acquired his very extensive and accurate knowledge of marine biology. In 342 B.C. at King Philip's request he went to Macedonia to undertake the education of Philip's son Alexander, then a boy of fourteen. But his tutorship cannot have lasted long, for two years later Alexander was entrusted with the government of Macedonia during Philip's absence and two years after that he fought at the battle of Chaeronea. There is no indication that Alexander learnt anything from Aristotle beyond a great admiration for Homer's 'Iliad', nor is there any sign that Aristotle approved of Alexander's career of conquest. From Macedonia Aristotle returned to Athens, where he opened a school of his own, called the Pesipatetic School. Here he taught for thirteen years. After Alexander's death all who had had anything to do with the Macedonians became unpopular at Athens, and Aristotle retired to Chalcis, where he died in 322 B.C.

The works which Aristotle published in his lifetime have all perished except the 'Constitution of Athens'. The rest of the works that have come down to us appear to have been notes for lectures. They form a considerable body of Greek. Nearly a third are works on biology; his 'Physics' and 'Metaphysics' and minor works on astronomy and cognate subjects amount to more than a fourth; of the rest the most important are his treatises on logic, and the 'Nicomachean Ethics' and the 'Politics'. He also wrote on rhetoric and poetry.

In ancient times Aristotle was respected for his immense learning, and the school which he founded lasted for nearly nine hundred years; but he and his followers were by no means as popular or as influential as the Stoics and Epicureans. When the conquests of the northern barbarians brought the Roman Empire in the west to an end, and the Arabs overran most of the Eastern Empire, it might have seemed that Greek learning was doomed to perish. But the Mahometans now began to study Greek science and philosophy, and Aristotle was translated into Arabic for them and was studied from Bokhara to Cordova. When during the last half of the 12th century universities came into existence north of the Alps, they turned eagerly to Latin translations of the Arabic translations of Aristotle. No other Greek philosopher had been translated into Arabic; so Aristotle was the one great philosopher of the ancient world whose works were studied, and his logic became the main subject in mediaeval university education. Further, a whole system of the theology was constructed on the basis of his metaphysics and this, too, took a prominent place in mediaeval thought. Hence Aristotle in the Middle Ages was, as Dante says, the master of those that know.

And we must not suppose that his usefulness is exhausted. Logic, which we owe to him, is undoubtedly a most valuable instrument of education. And there is still something to be learnt from his 'Ethics' and his 'Politics'.

9TH OCTOBER, 1944

A Special Meeting was held in the Society's Room on this date for the purpose of amending certain of the Society's Rules. The President, His Excellency the Governor, presided. The following amended Rules were agreed to by the Meeting:—

Rule 5.—After the words "Two Vice-Presidents" insert 'an Honorary Secretary'.
Rule 13.—After the first word of the Rule, insert 'Honorary Secretary, the Honorary'.
Rule 23.—Rule 23 to be deleted and the following new Rule to take its place:—

HONORARY SECRETARY

23. The Honorary Secretary shall, subject to these Rules and to any directions of the Council, exercise executive supervision of the affairs of the Society and of the Society's Library. He shall arrange the Meetings of the Society and Council, and shall see that Minutes of all Meetings of the Society and of the Council are faithfully kept and entered in Minute Books provided for the purpose.

Rule 33.—Rule 33 to be deleted and the following new Rule to take its place:—

33. All persons whose names appear on the Society's Roll as Ordinary Members shall pay an annual subscription as follows:—

(1) £1 10s. for those Ordinary Members who choose to receive the Papers and Proceedings; and
(2) £1 1s. for those Ordinary Members who do not wish to receive the Papers and Proceedings.

Rule 38.—Rule 38 to be deleted and the following new Rule to take its place:—

38. Any person between the ages of 18 and 21, or who is an undergraduate of the University of Tasmania, or who is a wife of a Life Member or an Ordinary Member of the Society and over 18 years of age, shall be eligible for election as an Associate Member.

Rule 43.—Add at the end of the Rule following the word 'Society'; 'Each Life Member shall receive a copy of the Papers and Proceedings for the year in which his subscription as a Life Member is paid and for each subsequent year, without further payment'.

Throughout the Rules substitute 'Honorary Secretary' for 'Secretary'.

9TH OCTOBER, 1944

A meeting was held in the Society's Room immediately after the Special Meeting. The President, His Excellency the Governor, presided.

Mr. C. H. Grant was elected a member of the Society.

It was announced that there had been enquiries from members as to whether membership of the Royal Society of Tasmania carried with it any privileges in the various Royal Societies in Australia. The Council has been in touch with all the Royal Societies on the mainland, with the result that a reciprocal arrangement has been established whereby members of the Royal Society of Tasmania, bearing a letter of introduction from the Secretary of the Society, will be allowed to use the Library and to attend meetings of the Royal Societies in the different States.

Death of Mr. E. E. Unwin:—The President spoke of the great loss which the Society had sustained by the death of Mr. E. E. Unwin, who had served on the Council for many years and who had also held the office of Vice-President on several occasions. He asked those present to stand in respect to Mr. Unwin's memory.

Mr. S. Angel exhibited specimens of *Alcidis zodiaca* from Queensland, *Papilio la Glaizei* and *Alcidis orontes* from New Guinea.

Mr. W. E. Masters delivered and illustrated lecture on 'The Early History of Salamanca Place', of which the following is an abstract:—

Salamanca Place has during the course of its history had several names. On 1st January, 1806, shortly after the settlement of the British at Sullivan's Cove, a location order vested in the Reverend Robert Knopwood, the chaplain, a large area of 30 acres of forest land extending along the boundary of the then burial ground (now St. David's Park), thence approximately along the lines of the present Harrington Street and Hampden Road nearly to what is now the Castray Esplanade (at one time known as 'Knopwood's Point'), and thence along the shoreline of the cove in an irregular line to the point of commencement.

Mr. Knopwood's home was at first situated at the rear of the spot where the Sailors' Home now stands, but later, when Montpelier Retreat was put through his location in 1831, he moved his home across the new road to a site on the other side of that road. The portion of Salamanca Place between Davey Street and Parliament House was never part of the located area in question.

In a memorandum read in the Executive Council on 12th September, 1831, the property so located to the chaplain was referred to as 'the Cottage Green property', the portion of the location on the waterfront being therein referred to as the 'New Wharf' in contradistinction to the old wharf which existed on portion of what is now known as Hunter Street at the other end of the cove. The name 'Salamanca Place' was given, in commemoration

of the victory of the Duke of Wellington over the French in 1812 in the province of Salamanca in Spain, to that portion of the located area corresponding with the area which is known to-day by that name. On 24th January, 1902, the area then known as the New Wharf was officially altered to 'Princes Wharf' to commemorate the landing there of the Duke and Duchess of York, later their Majesties King George V. and Queen Mary.

When Lieutenant-Governor David Collins and his party founded the settlement of Hobart Town in February, 1804, that corner of the cove was found to be an excellent anchorage, protected as it was from high southerly and south-westerly winds, the water being deeper there than on the northern end of the cove, the shore rising sharply from the water line to the higher ground at the rear of the present line of old warehouses between Montpelier Retreat and Runnymede Street. The corner of the cove near the present Parliament House was then a swamp, and the haunt of wildfowl, two rivulets flowing through the forest on to the beach, one along the present site of Montpelier Retreat and the other through the burial ground, now St. David's Park. Later in the history of Salamanca Place these creeks, or what was left of them as the drainage area was reduced, were confined to underground drains, which still exist and drain into the cove near Lurgurena Wharf. In early days, small bridges crossed the two creeks to enable foot passengers to cross from what is now Battery Point to the main settlement.

Mr. Knopwood was no business man and his property eventually passed out of his hands into the possession of a number of merchants, who built their small warehouses on the slope of the hill facing the cove. In 1818 Lieutenant-Governor Sorell built the Mulgrave battery (which gave Battery Point its name) on the site of the present Princes Park, and a roadway 33 feet wide leading from Davey Street through the Cottage Green property was resumed by the Crown to enable the gunners to proceed to the new battery. Shortly after the arrival in the Colony of Lieutenant-Governor Arthur in 1824 he set about improving the waterfront in the area by negotiating with the merchants there for a larger roadway, in addition to the narrow 33-feet road then recently resumed by the Crown, and for the carrying out of an extensive reclamation from the cove for the purposes of constructing a wharf to supply the increasing demand for the berthing of oversea ships which had for a few years been mooring to posts on the bank, the cargo being carried over long gangways reaching from the shore to the ships and the vessels themselves being kept off the bank by long poles.

The historical offer of the merchants made to the Lieutenant-Governor on 27th September, 1825, accepted by him on 6th December, 1825, and later confirmed in the Executive Council on 12th September, 1831, and which in later years led to a long, and at times bitter, conflict between the shipping merchants and the port authorities, were read by the lecturer. The merchants offered to cede to the Crown a space of 87 feet in front of their respective lots in addition to the 33-feet roadway to Mulgrave battery on condition that the whole quantity of 120 feet in breadth from high-water mark be applied to construction of a road 60 feet wide and the remainder used for public purposes only. This offer bore the names of ancestors of well known Hobart residents of to-day.

Lieutenant-Governor Arthur, in his agreement to accept the offer, intimated to the merchants that no buildings would be erected on the bank below the proposed road so high as to obstruct the view from the front of their lands and that the foundations of the buildings required for public purposes should be laid only so much above high-water mark as might be absolutely necessary to keep the stores dry.

In the confirmation made in September, 1831, provision was made for the opening of what is now Montpelier Retreat through the Cottage Green property, the whole of the strength of the prison gang to be employed on the work. Provision was also made for the projected new 60-foot road to be lowered to a level with the proposed wharf and the Crown engaged to excavate within three years an area 100 feet in depth back into the hillside from the edge of such road, sufficiently level for the erection of building thereon, and further, that a gang of not less than 100 men should be kept constantly at the work.

This agreement led to the making of the great cutting away of the hillside which can be clearly seen to-day at the rear of the warehouses, the debris being used to fill in the foreshore reclaiming the wharf area from the waters of the cove.

Trouble arose in 1851 when the Crown wished to erect a large bond in front of the merchants' warehouses for the use of the customs officers, as suggested in a letter from the Secretary of State for the Colonies.

The matter was submitted for the opinion of Mr. A. C. Stonor, the Crown Solicitor of the Colony, and to Mr. Valentine Fleming (later Sir Valentine Fleming) the then Attorney-General. The upshot of the matter was that it was decided that the Crown should erect a small one-storey building for use as a landing waiter's office on the waterfront. This was later erected and stood until removed in recent years when the new 80-feet concrete road was constructed. Lieutenant-Governor Arthur, however, made it quite clear that the acquiescence of the merchants in the erection of such building was not to be taken as an admission that the Crown had the right to construct any further buildings there.

The affairs of the port until 1858 were under the control of a port officer, whose jurisdiction and powers were never satisfactorily defined. In that year the Marine Boards (or Guilds) of Hobart and Launceston came into existence under statutory authority. Shortly afterwards disputes arose between the Hobart Marine Board and the merchants as to the rights of the Board over the five squares which had been constructed in Salamanca Place in front of the warehouses in accordance with the design of Mr. James Sprent (later Surveyor-General of the Colony) as part of a comprehensive survey of the city area. The Board claimed the right to let the squares at rentals for the storage of ships' gear, etc., and even to fence off any square and, if need be, erect buildings thereon.

The result was that the area became an unsightly dumping ground and a disgrace to the port. The trouble culminated when, in 1925, it was proposed that a large store or bond for case oil be erected on the squares in front of the warehouses. The Crown submitted the question to Mr. L. Chambers the Solicitor-General of the day who, in his opinion, traversed the history of the agreement of 1825 and advised that the Government should intimate to the Marine Board that any action so taken would be at the Board's exclusive risk and that the Government should not concur in the proposal. The Treasurer, Mr. J. A. Lyons, accepted this view, and later the Marine Board, on 23rd September, 1925 (almost exactly 100 years since the date of the merchants' offer to Lieutenant-Governor Arthur on 27th September, 1825), decided not to proceed with the oil store 'at present', but still maintained their claim to a right to erect buildings on the squares and let them without the consent either of the Government or the merchants.

To-day the site of the squares has no building whatever on it and is ready to be beautified by lawns and flower gardens when peace comes once again. The troubles as to the customs house and the oil store finally and peacefully settled themselves without the direct assistance of either side, the growing demand for the lighter fuel oils for internal combustion engines in motor-vehicles and boats created the necessity for the erection of bulk oil-tanks on the northern end of the cove, and the increasing business of the port in the vicinity of the docks necessitated the erection of the present customs house.

What the merchants and their successors in title feared was that Salamanca Place, if hidden by a row of high buildings on the area in front of their warehouses and closer to the wharves, would develop into a slum, as has so often happened in other ports in similar circumstances. The tendency in the modern layout of harbour frontages is to require that an ornamental space should be constructed between wharves and the nearest office areas, giving plenty of space for traffic, in addition to beautifying what is usually the front doorstep to a city. Our present City Council and Marine Board now work together in defined areas in perfect amity, with the sole view of improving our harbour front.

Such improvements are foreshadowed in a design at present under contemplation as part of a town planning scheme, a slide of which was shown, and an interesting comparison was made with a slide of a plan prepared as early as 1832 by Mr. George Frankland (later Surveyor-General of the Colony), whose skill as a surveyor was coupled with an artistic taste. If his design had been carried into effect at the time it might have made the quayside of our city one of the loveliest in the British Empire.

The name of the present 'Hotel Esplanade' (formerly the 'Rear Admiral Hornsby') recalls the fact that Salamanca Place was a favourite esplanade when bands of the ships of the Royal Navy gave concerts.

16TH OCTOBER, 1944

A Special Meeting was held in the Society's Room on this date. The President, His Excellency the Governor, presided. Approximately 360 members and invited guests were present.

Professor Sir Howard Florey, F.R.S., delivered an illustrated lecture entitled 'Penicillin'.

13TH NOVEMBER, 1944

A meeting was held in the Society's Room. Professor V. V. Hickman, Vice-President, presided.

Life Membership

The Chairman announced that Mr. C. H. Grant, who was elected a Member at the last General Meeting, had become a Life Member.

The following papers which had been submitted for publication in the Society's Journal were tabled, and it was agreed to submit them to the Standing Committee:—

Some Abnormal Conditions of the Reproductive System of the Saltwater Crayfish, *Jasus lalandii* (Milne Edwards). By Professor V. V. Hickman. (See page 57.)

Boomer Marsh—a prelimanry Botanical and Historical Survey. By Misses W. M. Curtis and J. Somerville.

New Trematodes from Tasmanian Fishes. By Mr. P. W. Crowcroft. (See page 61.)

Middle Miocene Limestones from King Island, Tasmania. By Miss Irene Crespin. (See page 13.)

Middle Miocene Limestone from Cape Barren Island, Furneaux Group, Bass Strait. By Miss Irene Crespin. (See page 15.)

Some Fossils from the Dundas Series, Dundas. By Dr. D. E. Thomas and Mr. Q. J. Henderson. (See page 1.)

A Critical Review of Tasmanian Graptolite Records. By Dr. D. E. Thomas. (See page 9.)

The Female Urogenital System and the Virginal Complex in the Marsupialia. By Dr. Joseph Pearson. (See page 71.)

Miss W. M. Curtis delivered an illustrated lecture entitled 'Plant Hormones', of which the following is an abstract:—

Although botanists borrowed the term 'hormone' from animal physiologists at the beginning of the century, it was not until 1928 that a hormone was actually extracted from a plant. Much difficulty was encountered in the early experimental work because of the very small quantities of hormones available. A new field of research opened up when in 1930-1933 it was found that certain substances extracted from yeast and from animal materials exerted physiological effects similar to those of plant hormones. Certain of these 'growth substances' have now been identified chemically and synthesised. Results of experiments with such growth substances, which are of fundamental importance in plant physiology, have certain practical applications. Some of the present commercial uses of growth substances are to stimulate the rooting of cuttings of both herbaceous and woody plants, to inhibit the development of buds during the storage of potatoes, to prevent the pre-harvest fall of apples and other fruits and to cause the development of seedless fruits in Solanums and other ornamental plants.

Northern Branch

No Reports have been received from the Northern Branch.

Obituary Notice

Ernest Ewart Unwin, M.Sc.

(1881-1944)

Ernest E. Unwin was born at Folkstone, Kent, in 1881 and died at Hobart on 20th September, 1944. He was educated at the Quaker School, Saffron Waldon, and at the Univeristy of Leeds, where he was admitted to the degree of Master of Science in 1906. During his university career he studied under the distinguished biologist, Professor L. C. Miall and his own life-long interest in biology may be partly attributed to the influence of this eminent teacher.

After graduating Ernest Unwin returned to the University of Leeds as Lecturer in Biology. He also taught at the Quaker Schools of Ackworth and Bootham and for eleven years was Housemaster at Leighton Park, Reading.

Accompanied by his wife and two young children he came to Tasmania in October, 1923, to take up his appointment as Headmaster of the Friends' School. Soon after his arrival in the State he became associated with the Royal Society of Tasmania and was elected a Member of the Society on 17th December, 1923. From that date to the time of his death he took an active interest in the work of the Society. In 1926 he was elected President of the Educational Section. He served as a member of the Council from 1926 to 1942 and was Vice-President of the Society during the years 1933-34 and 1940-41. On three separate occasions he was elected a Trustee of the Tasmanian Museum and Botanical Gardens. An able botanist and talented artist he gave valuable help to his fellow Trustees.

Ernest Unwin was a lucid and gifted speaker and this Society often had the privilege of hearing him lecture. He usually spoke on some aspect of biology or education and never lost an opportunity of stressing the importance of biology as a school-subject. In 1928, when the Australasian Association for the Advancement of Science met in Hobart, he wrote the article on Education in the 'Handbook to Tasmania' prepared for Members of the Association. He also read a paper, entitled 'Biology in Schools', before Section J (Education, Psychology, and Philosophy). One of the last lectures he delivered before the Royal Society of Tasmania was on the subject of 'Biology and Education'. In it he gave an interesting account of his personal experiences in the development of biology as a school-subject in England.

While at the University of Leeds he commenced a study of the respiratory organs of the Terrestrial Isopoda. This work was completed in Tasmania. An account of the research appeared in the Papers and Proceedings of this Society for the year 1931. In addition to the publications mentioned above he was also the author of three books, namely, 'Pond Problems', 'As a Man Thinketh', and 'Religion and Biology'.

No man has given greater service to the cultural life of this State than has Ernest Unwin. He was a past president of the Rotary Club; president of the Council of Churches on two occasions; Area Commissioner of Toc H in Tasmania;

a former member of the University Council; a past president of the Free Kindergarten Association; a founder and one-time chairman of the Executive of the Hobart Repertory Society; Vice-Patron and member of the Council of the Art Society; president of the New Education Fellowship; one-time member of the Tutors' Advisory Committee of the Workers' Educational Association; and a member of the State Advisory Council on Broadcasting.

His kindly and sympathetic personality, his sense of humour, and his readiness to give his time and talents in the service of others gained for him the esteem and goodwill, not only of the members of this Society, but of all those who were privileged to be associated with him.

V.V.H.

51533